DRAFT FEASIBILITY STUDY
OPERABLE UNIT THREE

W.R. GRACE SUPERFUND SITE
ACTON, MASSACHUSETTS

PREPARED FOR:

W.R. GRACE & CO. - CONN.
62 WHITTEMORE AVENUE
CAMBRIDGE, MASSACHUSETTS 02140

PREPARED BY:

GEOTRANS, INC.
6 LANCASTER COUNTY ROAD
HARVARD, MASSACHUSETTS 01451

GEOTRANS PROJECT NO.: 3008.002.57

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A TETRA TECH COMPANY
6 Lancaster County Road Harvard, Massachusetts 01451

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LIST OF ACRONYMS

1,2-DCA	1,2-dichloroethane
AAL	Allowable Ambient Limits
ARS	Aquifer Restoration System
ARARs	Applicable or Relevant and Appropriate Requirements
AUL	Activity and Use Limitation
AWD	Acton Water District
BERA	Baseline Ecological Risk Assessment
CCC	Chronic Criteria Continuous Concentration
COC	Contaminant of Concern
cfs	cubic feet per second
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMC	Acute Criteria Maximum Concentration
Dewey & Almy	Dewey and Almy Chemical Company
EO	Executive Order
FS	Feasibility Study
GAC	granulated activated carbon
gpm	gallons per minute
Grace	W.R. Grace & Co. - Conn.
GW	Groundwater
GWQS	Massachusetts Groundwater Quality Standards
ISCO	In-situ Chemical Oxidation
LEL	Lowest Effect Levels
LOAEL	lowest observed adverse effect level
MADEP	Massachusetts Department of Environmental Protection
MBTA	Massachusetts Bay Transportation Authority
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MCP	Massachusetts Contingency Plan
MMCL	Massachusetts Maximum Contaminant Level
MNA	Monitored Natural Attenuation
NCP	National Contingency Plan
NESHAP	national emission standards for hazardous air pollutants
NGVD	National Geodetic Vertical Datum of 1929
NOAEL	no observed adverse effect level
NRWQC	National Recommended Water Quality Criteria
O&M	Operations and Maintenance
ORSG	Massachusetts Office of Research and Standards Guidelines
OU	Operable Unit
PCB	poly-chlorinated biphenol
PEC	Probable Effects Concentration
PHRA	Public Health Risk Assessment
POTW	Publicly Owned Treatment Works
PRG	Preliminary Remediation Goal
RAO	Remedial Action Objective

RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SEL	Severe Effects Level
Site	W.R. Grace Superfund Site, Acton, Massachusetts
SOW	Statement of Work
SVOCs	semi-volatile organic compounds
TBC	To Be Considered
TEL	Threshold Effects Exposure Limit
USEPA	United States Environmental Protection Agency
UV	Ultraviolet
VDC	1,1-dichloroethene
VOCs	volatile organic compounds
WPA	Wetlands Protection Act

EXECUTIVE SUMMARY

1 INTRODUCTION

2 BASIS FOR SITE REMEDIATION

This section presents a summary of the regulatory requirements and remedial objectives for developing remedial alternatives for the W. R. Grace Acton Superfund Site. Section 2.1 identifies chemical, location, and action specific ARARs and Section 2.2 provides information on the development of Remedial Action Objectives (RAOs).

2.1 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This section provides a summary of the regulatory requirements to be used in the FS for the Site. Subsection 2.1.1 discusses the definition of ARARS; Subsection 2.1.2 identifies the categories of ARARS; Subsection 2.1.3 identifies chemical-specific ARARS; Subsection 2.1.4 identifies location - specific ARARS; and Subsection 2.1.5 identifies potential action-specific ARARs.

2.1.1 DEFINITION OF ARARS

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the 1986 Superfund Amendments and Reauthorization Act (SARA), and the National Contingency Plan (NCP) require that potential ARARs be identified during the RI/FS process. ARARs are federal and state human health and environmental requirements and guidelines that will be used to: (1) evaluate the appropriate extent of site cleanup (2) define and formulate remedial action alternatives; and (3) govern implementation and operation of the selected action.

To properly consider ARARs and to clarify their function in the RI/FS and remedial response processes, the NCP defines two ARAR components: (1) "applicable requirements" and, (2) "relevant and appropriate requirements." In addition, while not mentioned in CERCLA, EPA's Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA provides that other information, not meeting the definition of an ARAR, may also be considered. Such other information is referred to as "TBCs", or "to be considered." These terms are discussed in the following paragraphs.

Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a site. These include federal requirements that are directly applicable, as well as those incorporated by a federally authorized state program. Only those state standards identified by the state in a timely manner that are more stringent than federal requirements may be applicable.

Relevant and appropriate requirements are those cleanup standards, standards of control, or other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a Site, address problems or situations sufficiently similar to those encountered at the site that their use is well-suited to the particular site. There is more discretion in this determination in that it is possible for only part of a requirement to be considered relevant and appropriate, the rest being dismissed if judged not to be relevant and appropriate in a given case. Only those state standards identified by the state in a timely manner that are more stringent than the applicable federal standard may be relevant and appropriate.

TBCs are other "available information that is not an ARAR (e.g., advisories, criteria, and guidance)." Such TBCs "may be considered in the analysis if it helps to ensure protectiveness or is otherwise appropriate for use in a specific alternative."

Development of a comprehensive inventory of ARARs and TBCs involves a two-tiered analysis: establishing the applicability of an environmental regulation; and evaluating relevancy and appropriateness if the regulation is not applicable. A requirement may be either "applicable" or "relevant and appropriate," but not both.

2.1.2 IDENTIFICATION OF POTENTIAL ARARs

Because of their site-specific nature, identification of ARARs requires evaluation of the body of federal, state, and local environmental and health regulations with respect to chemicals of concern, site characteristics, and proposed remedial alternatives. Requirements that pertain to the remedial response at a CERCLA site can be placed into three categories:

- **Chemical-specific** requirements generally involve health- or risk-based numerical values or methodologies that establish site-specific acceptable chemical concentrations or amounts of a chemical that may be found in, or discharged to, the environment.

- **Location-specific** requirements involve restrictions established for specific substances or activities based on their location.
- **Action-specific** requirements involve performance, design, or other action-specific requirements and are generally technology- or activity-based.

A preliminary identification of probable ARARs, identifying potential chemical- and location-specific ARARs and TBCs, was submitted to the Government Parties in 2000 as Appendix C of the Phase 1 RI Work Plan (HSI GeoTrans, 2000). Because no specific remedial actions were identified until the FS was conducted, no action-specific ARARs were identified at that time. The following subsections identify ARARs and TBCs for the Site.

2.1.3 IDENTIFICATION OF CHEMICAL-SPECIFIC ARARS

Chemical-specific ARARs are numerical values or procedures that, when applied to a specific site or areas within a site, establish numerical limits for individual chemicals or groups of chemicals in one or more media. These ARARs are generally health- or risk-based standards limiting the concentration of a chemical found in or discharged to the environment. They govern the extent of site remediation by providing either actual cleanup levels, or the basis for calculating such levels. Table 2-1 presents potential chemical-specific ARARs and TBCs listed by media to which they may apply.

2.1.4 IDENTIFICATION OF LOCATION-SPECIFIC ARARS

Location-specific ARARs represent restrictions placed on the conduct of activities relative to natural site features (e.g. wetlands, water bodies, floodplains, sensitive ecosystems). Table 2-2 presents potential location-specific ARARs and TBCs identified for the Site.

2.1.5 IDENTIFICATION OF POTENTIAL ACTION-SPECIFIC ARARS

Action-specific ARARs, unlike chemical-specific and location-specific ARARs, are technology- or activity-based requirements that direct how remedial actions are conducted. The applicability of this set of requirements is directly related to the particular remedial activities considered for the site. Table 2-3 identifies those ARARs and TBCs that pertain to components of each of the remedial alternatives developed as part of this FS. The applicability of the action-specific ARARs pertinent to each specific remedial alternative will be discussed during the detailed analysis of remedial alternatives.

2.2 Development of Remedial Action Objectives

RAOs have been identified for each contaminated medium at the Site. RAOs consist of medium-specific or unit-specific goals for protecting human health and the environment. The RAOs for the Site are developed to assist in identifying a range of alternatives that may achieve protection of human health and the environment by reducing exposure to contaminated media.

The media of concern for the Site are groundwater as well as accessible sediment in Sinking Pond and the North Lagoon Wetland. These media were identified based on the results of the human health and ecological risk assessments described in Section 1.4 of this report. Section 2.2.1 develops RAOs, Preliminary Remediation Goals (PRGs), and general response actions for groundwater and Section 2.2.2 develops RAOs, PRGs, and general response actions for sediment.

2.2.1 Groundwater

The following sections develop RAOs, PRGs, and general response actions for groundwater.

2.2.1.1 Remedial Action Objectives

The RAOs for groundwater contamination at the Site are designed to provide adequate protection to human health and the environment from direct contact, ingestion, or inhalation of hazardous constituents that exist in the groundwater. As summarized in Section 1.4.1, the PHRA (Menzie-Cura, 2005a) identified potential human health risks above USEPA's cancer risk range and/or noncancer hazard index from future exposure to groundwater (tap water and irrigation water) in the six geographic areas of the Site. As a result of this potential risk, long-term groundwater response actions are necessary to protect human health.

The groundwater RAOs for protection of human health are:

- Prevent exposure to concentrations of contaminated groundwater from the Site that pose a potential cancer risk in excess of USEPA's cancer risk range and/or which exceed a target noncancer hazard index of one.

- Restore groundwater quality consistent with ARARs and PRGs so that the aquifer is suitable as a public water supply and for irrigation purposes.

2.2.1.2 PRELIMINARY REMEDIATION GOALS

Groundwater is the main medium of concern at the Site. Meeting the remedial goals for groundwater contamination will also serve to reduce risk to surface water and sediment in areas where Site-related contaminated groundwater discharges to surface water. The development of the PRGs for groundwater helps focus the development of remedial alternatives. The PRGs are developed to represent target risk-based concentrations (chemical-specific ARARs) and to meet the USEPA requirements for total allowable risk due to carcinogens (an excess upper bound lifetime cancer risk between 10^{-4} and 10^{-6}) and non-cancer hazards (a target-organ specific hazard index less than or equal to unity). PRGs for the protection of human health are developed in Appendix A and summarized below.

The PRGs for groundwater contamination are established based on the minimum concentration specified by any of the identified ARARs for the compounds that are dominant in the risk estimates (i.e. contribute to a cancer risk greater than 10^{-6} where the cumulative cancer risk exceeds 10^{-4} and/or exceed a target organ specific HI of 1) and exceed the corresponding ARAR. Manganese, is the one exception. USEPA has issued a Health Advisory on manganese of 300 µg/L, which is protective of adults and children. However, as discussed in Attachment A to Appendix A, the Health Advisory value of 300 µg/L is less than background concentrations for manganese. Therefore, the PRG for manganese will be consistency with the maximum background concentration. Table 2-7 summarizes the groundwater PRGs for each geographic area of the Site and indicates the cancer risk and non-cancer HI that will remain in each area of the Site once PRGs are attained. VDC is included in Table 2-7 for all six geographic areas of the Site, though it was only dominant in the risk estimate for the Southwest Landfill area. VDC is included because it is a precursor to vinyl chloride which is a dominant chemical in all six geographic areas of the Site.

Table 2-8 summarizes the Reasonable Maximum Exposure (RME) risk estimates that contribute to a cancer risk greater than 10^{-4} and/or a target-organ specific noncancer hazard index greater than 1, the pathways associated with these risk estimates, and the dominant chemicals contributing to these estimates as summarized in the PHRA (Menzie-Cura, 2005a). The table does not include areas where groundwater concentrations contributing to the risk estimates are consistently below the applicable ARARs, or chemicals which are naturally occurring inorganics detected very infrequently above ARARs (0.5 to 3% of the sampling locations) or are below maximum local background groundwater concentrations. Attachment A to Appendix A provides additional information regarding chemicals not included in Table 2-8.

Table 2-9 lists the number of locations at which the compounds listed in Table 2-8 exceed the PRG, the total number of locations for which the compound was analyzed, the mean concentration detected in each area, and the PRG for the compound. The maximum detected background concentration for manganese of 844 μg/L is used for screening purposes in Table 2-9.

As discussed in Section 1.3.1, the groundwater remedy will focus on the three main VOCs; VDC, vinyl chloride, and benzene. Other VOCs will be remediated as the VDC, vinyl chloride, and benzene are remediated, and inorganic compounds will be remediated as the original geochemistry of the Site groundwater is restored through treatment of VOCs and through the metals removal process of the new groundwater treatment system.

2.2.1.3 General Response Actions

Based on field data, the groundwater contamination extends over a large area (see Figures 1-3 through 1-6). VOCs have been identified in groundwater in the shallow and deep unconsolidated deposits and in the underlying bedrock to depths of more than 100 feet. Site data indicate that groundwater with concentrations that exceed PRGs is present beneath an area of approximately 250 acres. This estimate was calculated assuming that the extent of VOC contamination, as shown on Figure 1-6, represents the greatest areal extent of groundwater contamination. Potential general response actions for contaminated groundwater remediation at the Site include:

- No Action;
- Institutional Controls;
- Containment;
- Extraction/Removal/Collection/Discharge;
- In-situ Treatment;
- Ex-situ Treatment; and
- Residuals Management.

The No Action general response action would not address existing risk to human health and the environment at the Site. In this case, the No Action remedial alternative assumes the ARS is shut down and groundwater monitoring would be discontinued. The No Action response is included in this FS because it is required by the NCP as a baseline for evaluating other remedial alternatives.

2.2.2 SEDIMENT

The following sections develop RAOs, PRGs, and general response actions for sediment.

2.2.2.1 REMEDIAL ACTION OBJECTIVES

The RAOs for sediment are intended to provide adequate protection to human health and the environment from direct contact or ingestion of contaminated sediment. As summarized in Section 1.4.2, the PHRA (Menzie-Cura, 2005a) identified exceedances of USEPA's risk management criteria from exposure to accessible sediment in the North Lagoon Wetland and Sinking Pond. The BERA (Menzie-Cura, 2005b) identified risks to semi-aquatic wildlife and benthic invertebrates in sediment from the North Lagoon Wetland and Sinking Pond. Semi-aquatic wildlife are birds, mammals, and reptiles that spend time at, or feed in, a surface water body. Benthic invertebrates are macroscopic invertebrates that inhabit stream bottoms; freshwater forms are principally aquatic insects, clams, snails, crustaceans and worms.

As a result of this potential risk, long-term sediment response actions are necessary to protect human health and the environment. The sediment RAOs for protection of human health and the environment are:

- Control discharge of treated groundwater to prevent unacceptable impacts to sediment and surface water.
- Prevent exposure to sediment at the Site that presents an unacceptable human health or ecological risk.

2.2.2.2 PRELIMINARY REMEDIATION GOALS

The PRGs for sediment are to prevent exposure to sediment with Site-related contaminant concentrations above limits developed through the risk assessments. PRGs for the protection of human health and the environment are developed in Appendix A and summarized below.

PRGs for the Protection of Human Health

As stated above, the PHRA (Menzie-Cura, 2005a) identified exceedances of USEPA's risk management criteria from exposure to accessible sediment in the North Lagoon Wetland and Sinking Pond. Table 2-10 summarizes the RME risk estimates that contribute to a cancer risk greater than 10^{-4} and/or a target organ specific noncancer hazard index greater than 1, the pathways associated with these risk estimates, and the dominant chemicals contributing to these estimates as summarized in the PHRA (Menzie-Cura, 2005a). As indicated in Table 2-10, risks to humans are due to arsenic in accessible sediment in the North Lagoon Wetland and Sinking Pond. As discussed in Appendix A, sediment accessible to humans is defined as sediment that is consistently covered by two feet of surface water or less and where the ground slope is such that people could stand or walk comfortably. Accessible sediment is found in all areas of the North Lagoon Wetland. For Sinking Pond accessible sediment includes the inlet sediment, sediment on the western edge of the pond (Area SPBK-1 represented by samples SP-06 through SP-08 shown on Figure 1-14) and sediment on the southwestern edge of the pond (Area SPBK-2 represented by samples SP-18 through SP-20 shown on Figure 1-14). The remainder of the pond perimeter is not considered accessible to humans because the slope of the ground is too steep for someone to stand or walk comfortably for a long enough frequency/duration to result in risk. Therefore, in addressing sediment that poses risks to humans, the FS will address sediment with elevated arsenic concentrations in all portions of the North Lagoon Wetland, and in the inlet and on the western (SPBK-1 on Figure 1-14) and southwestern edge (SPBK-2 on Figure 1-14) of Sinking Pond that is consistently covered by two feet of surface water or less. For areas SPBK-1 and SPBK-2, the fluctuations in the surface water elevation of the pond will be taken into consideration in determining the location of accessible sediment. Historically the surface water elevation of the pond has fluctuated between approximately 144.5 feet NGVD and 140 feet NGVD. Therefore sediment within areas SPBK-1 and SPBK-2 between an elevation of 144.5 feet NGVD (the maximum surface water elevation of the Pond) and 138 feet NGVD (two feet below the minimum surface water elevation) will be evaluated. Also, additional sampling and consideration of slope changes will define the full areal extent of areas SPBK-1 and SPBK-2.

As discussed in Attachment A to Appendix A the PRG for arsenic in sediment is background, specifically

- the maximum background concentration of 28 mg/kg for the North Lagoon Wetland; and

- the maximum background concentration of 42 mg/kg for Sinking Pond.

The PRGs for Sinking Pond and the North Lagoon Wetland are summarized in Tables 2-11 and 2-12, respectively. Figures 1-15 and 1-16 show the arsenic concentrations in sediment near the North Lagoon Wetland and Sinking Pond, respectively. As shown on Figure 1-15, 16 of the 17 sediment samples near the North Lagoon Wetland have arsenic concentrations greater than the background concentration of 28 mg/kg. As shown on Figure 1-16, all four of the sediment samples from the inlet to Sinking Pond have arsenic concentrations greater than the background concentration of 42 mg/kg. Four of the six sediment samples in areas of Sinking Pond considered accessible to humans (SP-06, SP-07, SP-08, SP-18, SP-19, SP-20) have arsenic concentrations greater than the background concentration of 42 mg/kg.

PRGs for the Protection of the Environment

The BERA (Menzie-Cura, 2005b) identified risks to semi-aquatic wildlife and benthic invertebrates in sediment from the North Lagoon Wetland and Sinking Pond. PRGs for the protection of the environment are developed in Attachment B to Appendix A.

Risks to semi-aquatic wildlife are due to exposure to arsenic and manganese in accessible sediment in the North Lagoon Wetland and exposure to arsenic in accessible sediment in Sinking Pond. Semi-aquatic wildlife are birds, mammals, and reptiles that spend time at, or feed in, a surface water body. Risks to benthic invertebrates are likely due to elevated concentrations of arsenic and other metals (likely copper, iron, and manganese) in biologically active sediment. Benthic invertebrates are macroscopic invertebrates that inhabit stream bottoms; freshwater forms are principally aquatic insects, clams, snails, crustaceans and worms.

For the North Lagoon Wetland, all sediment above a depth of one-foot is considered accessible and biologically active to ecological receptors, and for Sinking Pond sediment in the inlet, as well as sediment around the entire perimeter of the pond that is consistently covered by twelve feet of surface water or less (the measured depth of the thermocline in late summer) is considered accessible and biologically active. Therefore, to address sediment that poses risks to ecological receptors, the FS will address sediment with elevated arsenic and manganese concentrations in the upper one foot of sediment in all portions of the North Lagoon Wetland, and sediment with elevated arsenic concentrations in the inlet to Sinking Pond as well as the entire perimeter of the pond that is consistently covered by twelve feet of surface water or less.

As stated above, the surface water elevation of Sinking Pond has fluctuated between approximately 144.5 feet NGVD and 140 feet NGVD. Therefore sediment within Sinking Pond between an elevation of 144.5 (the maximum surface water elevation of the Pond) and 128 feet NGVD (twelve feet below the minimum surface water elevation) will be evaluated.

The PRGs for Sinking Pond and the North Lagoon Wetland are summarized in Tables 2-11 and 2-12, respectively. For Sinking Pond both long-term and short-term PRGs have been established. The proposed long-term goal for arsenic for the protection of benthic invertebrates in sediment in Sinking Pond is the maximum background concentration of 42 mg/kg. This PRG applies to biologically active sediments (depths of 0 to 2 inches) in the biologically active parts of the pond (the inlet and the entire perimeter of the pond above the thermocline). A demonstrated trend in time toward background concentrations for arsenic in Sinking Pond sediment would be sufficient to determine that the long-term PRG for the pond is met. Initiating a trend toward maximum background for arsenic in Sinking Pond sediments is proposed to be established through several short-term actions including reducing metals loading from the ARS discharge as well as remediating sediments within the pond that meet certain criteria. For the short-term, actions to remove or isolate potentially toxic material from the biologically active portions of the pond (areas above the thermocline) along with monitoring and natural recovery would reduce metals loading in the pond and eventually result in a trend toward background arsenic concentrations in sediment. Therefore, short-term PRGs were developed to identify sediment to be addressed by remedial measures.

As discussed in Attachment B to Appendix A, the following short-term PRGs were developed to identify areas in the biologically active portions of Sinking Pond requiring remediation (the inlet and areas in the pond above the thermocline). In the inlet and four areas with shallow slopes (SPBK-1 through SPBK-4 on Figure 1-14) sediment meeting either of the following criteria will be remediated:

- Areas with arsenic concentrations in sediment of 730 mg/kg or greater (as discussed in Attachment B to Appendix A, this is the lowest arsenic concentration in Sinking Pond sediment at which toxicity was observed in sediment toxicity testing); or
- Areas with concentrations of the four metals identified as being consistently elevated in sediment above an effects-based benchmark (sediment with concentrations above the Probable Effects Concentration (PEC) for arsenic and copper, and the Severe Effects Level (SEL) for iron and manganese).

For areas within the pond above the thermocline but outside areas SPBK-1 through SPBK-4, the short-term goal is to identify areas meeting both criteria listed below and then to evaluate the need to remediate such areas based on risks, feasibility, and implementability:

- Areas with arsenic concentrations in sediment of 730 mg/kg or greater; and
- Areas with concentrations of the copper above the PEC and iron and manganese above the SEL.

The PRGs for the protection of benthic invertebrates in Sinking Pond will also be protective of semi-aquatic wildlife.

The PRGs for the protection of the environment from contaminated sediment in the North Lagoon Wetland are the maximum background concentration of 28 mg/kg for arsenic and the risk-based concentration of 2,030 mg/kg for manganese. As discussed in Attachment B to Appendix A, these PRGs apply to sediment to a depth of one foot, the depth to which semi-aquatic wildlife and benthic invertebrates may be exposed in a wetland.

2.2.2.3 General Response Actions

As described above, sediment requiring evaluation in this FS is present in the North Lagoon Wetland and Sinking Pond. The extent and volumes of sediment contamination within these areas have not been clearly defined. This will be done during the design phase. Regardless, the general response actions that are potentially applicable to sediment at the Site include:

- No Action;
- Institutional Controls;
- Containment;
- Removal;
- In-situ Treatment; and
- Ex-situ Treatment.

The No Action alternative would result in no changes to the sediment contamination, and is required by the NCP.

3 IDENTIFICATION AND SCREENING OF APPLICABLE TECHNOLOGIES

Potentially applicable technology types and process options for each contaminated medium at the Site are identified in this Section. The potentially applicable technology types and process options for groundwater and sediment, listed in Tables 3-1 and 3-2, respectively, were derived from those identified in other RODs, experience with similar types of contaminants, and other databases. The following on-line databases were accessed to identify potentially relevant technology types and process options:

(1) The Federal Remediation Technologies Roundtable, a venture between various federal government agencies (www.frtr.gov); and

(2) The EPA Remediation and Characterization of Innovative Technologies - REACH IT (www.epareachit.org).

As defined in the USEPA FS guidance document (USEPA, 1988), the term "technology type" refers to general categories of technologies, such as biological treatment, physical treatment, capping, and extraction. The term "process options" refers to specific processes within each remedial technology type.

The identification of remedial technologies for the Site was derived from the previously mentioned sources. Several steps of screening were conducted prior to selecting the most promising technologies to be assembled into remedial alternatives for the Site. The initial evaluation, or initial screening was done to reduce to a manageable number those technologies that were potentially applicable to the Site prior to performing a more stringent screening. During the initial screening step, process options and entire technology types were evaluated on the basis of technical implementability. Those process options and technology types that could not be implemented effectively were eliminated from further consideration. Site information was used to screen out technology types and process options that could not be effectively implemented at the Site. Tables 3-1 and 3-2 summarize the initial technology screening process for groundwater and sediment, respectively.

4 DEVELOPMENT OF REMEDIAL ALTERNATIVES

Section 3 screened potential technologies to address remaining groundwater and sediment contamination at the Site on the basis of technical implementability. This section reviews those technologies that have moved forward in the screening process on the basis of effectiveness, implementability and cost and then assembles the remaining technologies into remedial alternatives. Where alternatives presented an issue as to any of these screening criteria that would prevent a technology from moving forward into the next step of the analysis, the issue was noted. Where there are a number of cleanup options within a technology type, a representative option(s) was selected to move forward in assembling alternatives. Sections 4.1 and 4.2 develop and assemble remedial alternatives for groundwater and Sections 4.3 and 4.4 develop and assemble remedial alternatives for sediment.

4.1 GROUNDWATER REMEDIAL ALTERNATIVE COMPONENTS

Table 4-1 screens the groundwater process options that moved forward from the initial screening process done in Table 3-1 on the basis of effectiveness, implementability and cost. Process options retained from this secondary screening are assembled into groundwater remedial alternatives in Section 4.2.

4.2 GROUNDWATER REMEDIAL ALTERNATIVES

Groundwater remedial alternatives are developed based upon those technologies and process options that were carried forward from the previous section. In assembling groundwater alternatives, the general response actions and the process options chosen to represent the various technology types for groundwater are combined to form alternatives for the Site as a whole. The following groundwater alternatives have been assembled and will be discussed further in Section 5:

Groundwater Remedial Alternatives						
	GW-1: No Action	GW-2: Limited Action	GW-3: Active Remediation			
Potential Components			Groundwater Extraction with Ex-Situ Treatment	In-Situ Chemical Oxidation	In-Situ Enhanced Bioaugmentation	Monitored Natural Attenuation
No Action	X					
Deed Restrictions		X	X	X	X	X
Groundwater Monitoring		X	X	X	X	X
Groundwater Extraction			X			
Surface Water Discharge			X			
Reinjection Wells			X			
In-Situ Chemical Oxidation				X		
In-Situ Bioaugmentation					X	
MNA			X	X	X	X
Air Stripping			X			
GAC			X			
Chemical Precipitation			X			
Liquid-Phase Separation by Gravity			X			
Filter Press			X			
GAC Adsorption			X			
Off-Site Regeneration			X			

Additional information regarding the components of the groundwater remedial alternatives is included in Table 4-2.

4.3 Sediment Remedial Alternative Components

Table 4-3 screens the sediment process options that moved forward from the initial screening process done in Table 3-2 on the basis of effectiveness, implementability and cost.

Process options retained from this secondary screening are assembled into sediment remedial alternatives in Section 4.4.

4.4 ASSEMBLE SEDIMENT REMEDIAL ALTERNATIVES

Sediment remedial alternatives are developed based upon those technologies and process options that were carried forward from the previous section. In assembling sediment alternatives, general response actions and the process options chosen to represent the various technology types for sediment are combined to form alternatives for Sinking Pond and the North Lagoon Wetland. The following sediment alternatives have been assembled and will be discussed in Section 5:

SEDIMENT REMEDIAL ALTERNATIVES			
SINKING POND			
COMPONENTS	**SP-SED-1: NO ACTION**	**SP-SED-2: LIMITED ACTION**	**SP-SED-3: ACTIVE REMEDIATION**
No Action	X		
Access/Deed Restrictions		X	X
Monitoring		X	X
Capping/burial with Clean Fill/Gravel			X
Dredging			X
On-Site Disposal			X
Off-Site Disposal			X
Monitored Natural Attenuation			X
NORTH LAGOON WETLAND			
COMPONENTS	**NLW-SED-1: NO ACTION**	**NLW-SED-2: LIMITED ACTION**	**NLW-SED-3: ACTIVE REMEDIATION**
No Action	X		
Access/Deed Restrictions		X	X
Monitoring		X	X
Capping/burial with Clean Fill/Gravel			X
Dredging			X
On-Site Disposal			X
Off-Site Disposal			X
Monitored Natural Attenuation			X

Additional information regarding the components of the sediment remedial alternatives is included in Tables 4-4 and 4-5 for Sinking Pond and the North Lagoon Wetland, respectively.

5 ALTERNATIVES SCREENING PROCESS

Chapter 4 presented additional screening of technology types and process options on the basis of effectiveness, implementability, and cost and then assembled a range of alternatives. Chapter 5 screens the entire assembled alternatives (as defined in Tables 4-2, 4-4, and 4-5) on the basis of effectiveness, implementability, and cost. The comparison between alternatives in this screening step is generally made between similar alternatives. The screening criteria are defined as follows:

EFFECTIVENESS

- Overall protectiveness of human health and the environment;
- Compliance with remedial goals;
- Reduction of toxicity, mobility, or volume of contaminants; and
- Adverse short- and long-term effects caused by implementation.

IMPLEMENTABILITY

- Technical feasibility;
- Demonstrated performance;
- Availability of equipment, space, and services; and
- Administrative feasibility.

COST

- Equipment/construction; and
- Operation and maintenance.

Alternative screening for groundwater and sediment are included in Sections 5.1 and 5.2, respectively.

5.1 GROUNDWATER REMEDIAL ALTERNATIVES

The remedial alternatives for groundwater developed in Section 4 are:

- Alternative GW-1: No Action
- Alternative GW-2: Limited Action
- Alternative GW-3: Active Remediation

These alternatives are described and screened in Sections 5.1.1 through 5.1.3, respectively.

5.1.1 ALTERNATIVE GW-1: NO ACTION

Consistent with EPA guidance and legal requirements, the No Action Alternative serves as a baseline by which all other alternatives are compared. This alternative would require that the

ARS no longer operates. Therefore, groundwater conditions at the Site would revert to natural hydrologic processes. Under this alternative, natural attenuation, including dilution, natural biological and chemical degradation, adsorption, and precipitation would likely reduce the concentrations of groundwater contamination. However, no monitoring would be done to evaluate changes in groundwater quality or risks to human health and the environment.

The effectiveness, implementability, and cost associated with the No Action Alternative for the entire Site are evaluated in Table 5-1. The conclusion of the evaluation is that the No Action Alternative would not be protective of human health and the environment. The No Action Alternative, however, is retained for detailed analysis as required by the NCP as a baseline for evaluating the remaining alternatives.

5.1.2 ALTERNATIVE GW-2: LIMITED ACTION SITE-WIDE

This alternative would restrict/prevent direct contact with contaminated groundwater. This alternative assumes that the existing ARS pumping wells would no longer be in operation. Institutional controls would be put in place to prevent human exposure to contaminated water and monitoring would be conducted to determine the changes in contaminant concentrations over time. Under this alternative, natural attenuation, including dilution, natural biological and chemical degradation, adsorption, and precipitation would likely reduce the concentrations of groundwater contamination. ARS extraction wells would be abandoned in accordance with applicable Massachusetts regulations. Institutional controls would be implemented to restrict use of, and exposure to, contaminated groundwater throughout the duration of the remedial action. These controls would include restrictions on the installation of private wells within one or more specified areas. In addition, Grace would restrict the use of groundwater on its property. In the event that the Grace property is sold, appropriate restrictions would be included in any deeds. Groundwater would be periodically monitored according to a plan which would be developed during the remedial design after the ROD is signed.

The effectiveness, implementability, and cost associated with the Limited Action Alternative are evaluated in Table 5-2. The conclusion of the evaluation is that the Limited Action Alternative would be protective of human health and the environment by limiting exposure to contaminated groundwater. Contaminant concentrations would be reduced by natural attenuation processes. This alternative is retained for detailed analysis.

5.1.3 ALTERNATIVE GW-3: ACTIVE REMEDIATION

This alternative is intended to provide active remediation to contaminated groundwater at the Site. Process options that were considered include:

- Groundwater Extraction with Ex-Situ Treatment;
- In-Situ Chemical Oxidation;
- In-Situ Enhanced Bioaugmentation; and
- Monitored Natural Attenuation (MNA).

Because of its wide-spread use in general, and demonstrated effectiveness at the Site to date, groundwater extraction with ex-situ treatment combined with MNA were chosen as the appropriate technologies for this Active Remediation Alternative. In-Situ Chemical Oxidation and In-Situ Enhanced Bioaugmentation were also considered and evaluated in the Alternatives Screening. However, as shown in Tables 5-3 and 5-4, both of these technologies presented effectiveness and implementability limitations. In particular, the number of wells that would be necessary to effectively distribute the oxidant or nutrients throughout the Site and the potential impacts of unreacted oxidant to groundwater extraction and treatment equipment are major disadvantages to these in-situ technologies being retained for further evaluation.

The Active Remediation Alternative, consisting of groundwater extraction with ex-situ treatment and MNA, would restrict/prevent direct contact with contaminated groundwater. Under this alternative, groundwater extraction wells would be designed to capture groundwater in specified areas. Contaminated groundwater outside the capture zone would be remediated through natural attenuation processes. Groundwater from the extraction wells would be transported to a new treatment system via underground piping. Based on the results of treatability testing done at the Site for inorganic compound removal and the operational performance of the current VOC removal technology, chemical precipitation for the removal of inorganic compounds and air stripping coupled with off-gas treatment using granular activated carbon (GAC) for the removal of VOCs would be used to treat the groundwater. The treated water would be discharged to Sinking Pond with some groundwater potentially reinjected back into the ground. Groundwater monitoring would be done to evaluate the effectiveness of the remedy. Institutional controls would be implemented to restrict use of, and exposure to, contaminated groundwater throughout the duration of the remedial action. These controls would include restrictions on the installation of private wells within a specified area. In addition, Grace would restrict the use of groundwater on its property. In the event that the Grace property is sold, appropriate restrictions would be included in any deeds. Groundwater would be periodically monitored according to a plan which would be developed during the remedial design after the ROD is signed.

The effectiveness, implementability, and cost associated with the Active Remediation Alternative, consisting of groundwater extraction with ex-situ treatment and MNA for the Site are evaluated in Table 5-5. The conclusion of the evaluation is that the Active Remediation Alternative would be protective of human health and the environment by actively treating and limiting exposure to contaminated groundwater. Contaminant concentrations would be reduced by groundwater extraction and treatment as well as by natural attenuation processes. This alternative is retained for detailed analysis.

5.2 SEDIMENT REMEDIAL ALTERNATIVES

The initial screening of alternatives for sediment in Sinking Pond and the North Lagoon Wetland are included in Sections 5.2.1 and 5.2.2, respectively.

5.2.1 SINKING POND

The three remedial alternatives developed in Section 4 for the sediments in Sinking Pond are:

- Alternative SP-SED-1: No Action;
- Alternative SP-SED-2: Limited Action; and
- Alternative SP-SED-3: Active Remediation.

These three alternatives are described and screened in Sections 5.2.1.1 through 5.2.1.3, respectively.

5.2.1.1 ALTERNATIVE SP-SED-1: NO ACTION

This alternative consists of no remedial activities beyond those which have already been conducted at the Site, and it represents the minimum proposed remedial action for sediments in Sinking Pond. No changes would be made to Sinking Pond sediments specifically with respect to sediment quality. Any changes that occurred in this area would result from potential changes in the groundwater treatment system discharge quality. Under this alternative, natural attenuation by redistribution, dilution, and natural burial would reduce the exposure point concentrations in the targeted sediments. However, no monitoring would be done to evaluate changes in sediment quality or risks to human health and the environment.

The effectiveness, implementability, and cost associated with the No Action Alternative for Sinking Pond are evaluated in Table 5-6. The conclusion of the evaluation is that the No Action Alternative would not be protective. The No Action Alternative, however, is retained for detailed analysis as required by the NCP as a baseline for evaluating the remaining alternatives.

5.2.1.2 ALTERNATIVE SP-SED-2: LIMITED ACTION

This alternative provides no treatment, but provides protection to human health by preventing or controlling potential exposures to contaminated sediments through institutional controls and environmental monitoring. Access would be limited through construction of fencing around impacted sediments. A monitoring plan would be developed to assess the effectiveness of the access restrictions in place and to assess changes in sediment quality in the Sinking Pond inlet area and in the Pond itself. Although changes in the discharge to the Pond may effect sediment quality in the future, the impacts and timeframe are difficult to assess. As a result, this alternative is not effective in preventing unacceptable exposure to ecological receptors.

The effectiveness, implementability, and cost associated with the Limited Action Alternative for Sinking Pond are evaluated in Table 5-7. The conclusion of the evaluation is that the Limited Action Alternative would not be protective of the environment. Therefore, this alternative is not retained for detailed analysis.

5.2.1.3 ALTERNATIVE SP-SED-3: ACTIVE REMEDIATION

This alternative was developed to remediate those sediments which were deemed to pose risks to either human health or the environment. It includes excavation of the sediments at the Sinking Pond inlet as well as removal and/or burial/capping of sediments from select portions of the Pond that are above the thermocline and considered to pose risk to either human health or to environmental receptors. Specific criteria for attainment of PRGs are discussed in greater detail in Section 2.2.2 and summarized in Table 2-11. Locations of specific areas that will be targeted for cleanup will be better defined by additional laboratory analysis performed as part of a field program implemented to support design criteria development. Excavated sediments would be stockpiled on-site for dewatering. Off-site disposal of dewatered sediment cake is anticipated, but on-site disposal options would be considered once post-dewatering characteristics can be adequately assessed. As part of this option, the inlet area would be redesigned to develop a less turbulent flow regime in the event that discharges to the pond were to continue. This may consist of a widened inlet mouth and design of a flow dampening hydraulic control, such as an overflow weir. In addition, the pond bank in the area of the former Pump House would be restored.

The effectiveness, implementability, and cost associated with this alternative are evaluated in Table 5-8. The conclusion of the evaluation is that the removal and/or burial/capping of the targeted sediments would be protective of human health and the environment by eliminating potential for exposure to sensitive receptors at the site. Therefore, this alternative is retained for detailed analysis.

5.2.2 NORTH LAGOON WETLAND

The three remedial alternatives developed in Section 4 for the sediments in the North Lagoon Wetland are:

- Alternative NLW-SED-1: No Action;
- Alternative NLW-SED-2: Limited Action; and
- Alternative NLW-SED-3: Active Remediation.

These three alternatives are described and screened in Sections 5.2.2.1 through 5.2.2.3, respectively.

5.2.2.1 ALTERNATIVE NLW-SED-1: NO ACTION

The No Action Alternative was developed for consideration throughout the FS process as a baseline for evaluating other alternatives. The alternative does not require additional activities to take place, and represents the minimum proposed remedial action for sediments at the North Lagoon Wetland.

The effectiveness, implementability, and cost associated with the No Action Alternative for the North Lagoon Wetland are evaluated in Table 5-9. The conclusion of the evaluation is that the No Action Alternative would not be protective. The No Action Alternative, however, is retained for detailed analysis as a baseline for evaluating the remaining alternatives as is required by the NCP.

5.2.2.2 Alternative NLW-SED-2: Limited Action

This alternative provides no treatment, but provides protection to human health by preventing or controlling potential exposures to contaminated sediments through institutional controls and environmental monitoring. Access would be limited through construction of fencing around impacted sediments. It is possible that elevated and actionable levels of arsenic and manganese observed in the North Lagoon Wetland sediments are the result of groundwater discharge to the wetland with consequent precipitation of these metals. As a result, changes in sediment quality may occur over time through the redistribution of existing sediments during storm events.

Although changes in sediment quality may occur in the future, the impacts and timeframe are difficult to assess. A monitoring plan would be developed to assess the effectiveness of the access restrictions and to assess changes in sediment quality in the North Lagoon Wetland. This alternative does not restrict access to sediment that presents an unacceptable risk to ecological receptors. Therefore, this alternative is not effective in protecting ecological receptors.

The effectiveness, implementability, and cost associated with the Limited Action Alternative for the North Lagoon Wetland are evaluated in Table 5-10. The conclusion of the evaluation is that the Limited Action Alternative would not be effective, as ecological receptors would continue to be exposed to unacceptable risk for unknown periods of time. In addition, it is uncertain when or if contaminant concentrations would be reduced to remedial goals by redistribution, dilution, and natural burial processes. Therefore, this alternative is not retained for detailed analysis.

5.2.2.3 Alternative NLW-SED-3: Active Remediation

This alternative was developed to prohibit access to those sediments which were deemed to pose either human health or ecological risks under the current risk characterization through a combination of methods that may include excavation, off-site disposal, on-site disposal, and burial in-place. The specific PRGs are summarized in Table 2-12. Locations of specific areas that will be targeted for cleanup will be better defined by additional laboratory analysis performed as part of a field program implemented to support design criteria development.

This alternative requires excavation of at least a portion of the impacted sediments in the North Lagoon Wetland. It is anticipated that some excavation will be required in the portion of the North Lagoon Wetland sediments that reside within the 100-year flood plain of Fort Pond Brook. Consideration will be given to burial-in-place for North Lagoon Wetland sediments outside of the 100-year floodplain. The location of the 100-year flood plain for Fort Pond Brook is shown on Figure 1-15. Either off-site disposal or on-site burial/capping of dewatered wetland sediments may be implemented, based in part on the characteristics of the dewatered sediments. It is assumed that average excavation depths would be less than one foot throughout most of the targeted areas, and that full wetland restoration or replication efforts would be implemented in accordance with applicable regulations and industry standards.

The effectiveness, implementability, and cost associated with this alternative are evaluated in Table 5-11. The conclusion of the evaluation is that the removal and/or burial-in-place of the targeted sediments would be protective of human health and the environment by eliminating potential for exposure to sensitive receptors at the site. Therefore, this alternative is retained for detailed analysis.

6 DETAILED ANALYSIS OF ALTERNATIVES

The purpose of this detailed analysis of alternatives is to allow for comparisons among the groundwater and sediment remedial alternatives based on the standard criteria specified in the NCP. Nine evaluation criteria were developed by EPA to serve as the basis for the detailed analysis of alternatives. These criteria are set forth in the NCP, at 40 CFR § 300.430(e)(9). Further detail is provided in EPA's "Guidance for Conducting Remedial Alternatives and Feasibility Studies Under CERCLA" (US EPA, 1988). The nine criteria are summarized below.

1. Overall protection of human health and the environment: This criterion focuses on whether a specific alternative achieves adequate protection and how site risks for each migration pathway being addressed by the FS are eliminated, reduced, or controlled through treatment, engineering, or institutional controls. Also considered are whether an alternative poses any unacceptable short-term or cross-media impacts.
2. Compliance with ARARs: Assessment against this criterion describes how the remedial alternative complies with chemical-, location-, and action-specific ARARs, or if a waiver is required and how the waiver is justified.
3. Long-term effectiveness and permanence: This criterion pertains to the risks remaining after response objectives have been met. Three factors to be considered are the magnitude of the residual risk, the adequacy and reliability of any controls used to manage treatment residuals or untreated wastes that remain at the site, and the permanence of the remedy.
4. Reduction of toxicity, mobility, or volume: This criterion reflects the statutory preference for treatment alternatives that permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances. Preferred alternatives destroy toxic contaminants, reduce the total mass of toxic contaminants, irreversibly reduce contaminant mobility, or reduce the total volume of contaminated media.
5. Short-term effectiveness: This criterion refers to the protection an alternative offers to workers and the community during the construction and implementation of a remedy as well as the time required to reach the response objectives.
6. Implementability: This criterion considers technical feasibility, administrative feasibility, and the availability of required materials and services. *Technical feasibility* is evaluated on the basis of four parameters: ability to construct the alternative, the reliability of the technologies proposed, the ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy. *Administrative feasibility* considers activities needed to coordinate with other agencies, such as permits and rights-of-way.
7. Cost: This criterion evaluates the capital and operation and maintenance (O&M) costs of each alternative. Costs are present worth cost estimates.

8. State acceptance: This criterion evaluates the technical and administrative issues and concerns the state may have regarding each alternative. This criterion is not addressed in this report. It will be addressed in the ROD after comments on the RI/FS and proposed plan have been received.
9. Community acceptance: This criterion evaluates the issues and concerns the public may have regarding each alternative. This criterion is not addressed in this report. It will be addressed in the ROD after comments on the RI/FS and proposed plan have been received.

The detailed analysis for each alternative includes a detailed description of each remedial alternative followed by a detailed evaluation of each remedial alternative evaluation criteria 1 through 7. Criteria 1 and 2 are considered to be "threshold factors", criteria 3 through 7 are considered to be the primary "balancing factors" and criteria 8 and 9 are considered to be "modifying considerations".

The descriptions of each remedial alternative are conceptual and are used for costing purposes. The specific design details and costs for the selected remedy will be re-evaluated during the remedial design. As specified in the FS guidance (USEPA, 1988), the costs are intended to be within the target accuracy range of -30 to +50 percent of the actual cost. Section 6.1 presents the detailed analysis of alternatives for groundwater that were retained from the Alternatives Screening in Section 5. Section 6.2 presents the detailed analysis of alternatives for sediment that were retained from the Alternatives Screening in Section 5.

6.1 GROUNDWATER

Three groundwater remedial alternatives have been retained for detailed analysis. They are:

- Alternative GW-1: No Action;
- Alternative GW-2: Limited Action; and
- Alternative GW-3: Active Remediation consisting of Groundwater Extraction with Ex-Situ Treatment and MNA.

To assist in evaluating the various remedial alternatives, the publicly available groundwater flow and contaminant transport modeling source codes MODFLOW (McDonald and Harbaugh, 1988) and MT3DMS (Zeng and Wang, 1998) were used to develop a Site-wide groundwater flow and chemical transport model. GWVISTAS (Environmental Simulations, version 4) was used as a pre- and post-processor for the simulation codes. Details regarding the development and calibration of the groundwater flow model are included in the RI Report (GeoTrans, 2005). Details regarding calibration of the transport model and use of the groundwater flow and chemical transport model for the FS are included in Appendix B of this FS Report.

Contaminant transport modeling was done for VDC-contaminated groundwater Site-wide, and for benzene-contaminated groundwater in the Southeast Landfill Area. VDC and benzene were chosen as representative compounds on which to base remedy selection because their combined geographic distribution encompasses all VOC-contaminated groundwater at the Site. Vinyl chloride, the other main VOC at the Site, is a breakdown product of VDC and is found in a similar geographic area, though generally at lower concentrations than VDC. An analysis of available water quality data indicates that at approximately 85 percent of the locations where the VDC concentration is less than its MCL of 7 μg/L, the vinyl chloride concentration is also less than its MCL of 2 μg/L. Therefore, the estimated clean-up time for VDC should also approximate the clean-up time for vinyl chloride. The observed 2001-2002 VDC and benzene concentrations were used to describe the "current" distribution of contaminated groundwater for the model analyses of future groundwater conditions. These data are referred to in this report as the fall 2001 sampling event because the vast majority of the samples were collected in fall 2001. The fall 2001 groundwater quality data were selected to describe the current contaminant distribution used in the model because they are the most recent groundwater sampling results that were fully validated as part of the RI, and they are also the data that were used for the PHRA.

For VDC, the same initial contaminant distribution and transport parameters were used to evaluate each of the remedial alternatives. This allowed for a relative comparison of the model-calculated clean-up times for VDC-contaminated groundwater in different areas of the Site under natural attenuation as well as for various groundwater extraction scenarios. The only differences in the transport model simulations done to compare different pumping scenarios for VDC-contaminated groundwater would be the pumping details that made the remedial alternative unique to a particular area. In other words, one groundwater extraction scenario may have included groundwater extraction at six locations, and a second scenario may have included groundwater extraction at two locations. The only difference between the transport simulations for these two groundwater extraction scenarios would be the location and rates of the groundwater extraction. A similar procedure was used for benzene, where the same initial contaminant distribution and transport parameters were used to evaluate each groundwater extraction scenario for benzene-contaminated groundwater.

For purposes of this FS evaluation, groundwater clean-up was defined to have been achieved when the maximum model-calculated concentration of the VOC of interest, either VDC or benzene, was reduced to the MCL. These model-calculated clean-up times were used to estimate the operation and maintenance costs of the various groundwater extraction scenarios. Due to the hydrogeologic complexity of the Site and the approximations that were required for the contaminant transport modeling, the model-calculated clean-up times are approximate times and are not expected or intended to represent precise clean-up times for the Site. As described in Appendix B, however, the results of the model calibration and sensitivity analysis demonstrate that the model is a reasonably good representation of the Site, and the model was a useful and valuable tool for evaluating and comparing remedial alternatives for Site groundwater.

Remediation of VOC-contaminated groundwater is expected to also address the reducing conditions by which inorganic compounds such as arsenic and manganese have been mobilized. Therefore, remediation of inorganic compounds in groundwater is expected to occur as a result of VOC-contaminated groundwater remediation and restoration to more aerobic conditions in the aquifer (see Draft RI Report, Section 3.5, GeoTrans, 2005). The timeframe for inorganic compounds to reach remedial goals will be dependent on local groundwater conditions and is likely to be longer than the timeframe for VOCs to reach remedial goals. The change in geochemical conditions resulting from remediation of VOC-contaminated groundwater and the transition to aerobic groundwater conditions will be verified through a long-term groundwater monitoring program that is included as part of recommended groundwater remediation alternative presented in this FS.

For the No Action and Limited Action Alternatives, the contaminant transport model was used to estimate clean-up times based on a groundwater flow regime that was influenced by natural attenuation and the Town of Acton's five Public Water Supply wells. The model used the fall 2001 VDC concentrations as the initial contaminant distribution and was run forward in time to evaluate when, to the nearest year, the maximum VDC concentration in groundwater in each geographic area of the Site would be reduced to 7 μg/L. A similar procedure was followed to estimate when the maximum benzene concentration in the Southeast Landfill Area groundwater would be reduced to 5 µg/L.

For the Active Remediation Alternative, in which both groundwater extraction with ex-situ treatment and MNA would reduce contaminant concentrations to MCLs, the groundwater flow and contaminant transport model was used to evaluate the extent of groundwater capture for various pumping scenarios as well as clean-up times. First, the groundwater flow model was used to determine the number, location, and pumping rates of groundwater extraction wells needed to capture groundwater within the areas specified on Figure 6-1. For the Northeast Area, use of injection wells in combination with extraction wells was also considered. The capture areas specified on Figure 6-1 represent the minimum area within which groundwater was targeted for capture under each pumping scenario evaluated. The model-calculated capture areas under each of the pumping scenarios are larger than what is shown on Figure 6-1. The groundwater extraction and injection wells were incorporated into the contaminant transport model. The transport model, with the necessary extraction and injection wells, used the fall 2001 VDC concentrations as the initial contaminant distribution and was run forward in time to evaluate when, to the nearest year, the maximum VDC concentration in each of the six geographic areas would be reduced to 7 µg/L. The five Acton Public Water Supply wells were assumed to be active in these simulations. A similar procedure was followed to estimate when the maximum benzene concentration in the Southeast Landfill Area groundwater would be reduced to 5 µg/L.

6.1.1 ALTERNATIVE GW-1: NO ACTION

The No Action Alternative is included as a baseline against which other remedial alternatives can be compared.

DESCRIPTION

As required under CERCLA, the No Action Alternative would be applied Site-wide. The No Action Alternative assumes that the ARS would no longer operate. Under this alternative, natural attenuation processes, such as dilution, dispersion, natural biological and chemical degradation, adsorption, and precipitation would likely reduce the concentrations of groundwater contamination to remedial goals. However, no monitoring would be done to determine when remedial goals were reached. The groundwater flow and chemical transport model was used to estimate the time for VDC concentrations in groundwater to be reduced to the remedial goal of 7 µg/L site-wide and benzene concentrations to be reduced to the remedial goal of 5 µg/L in the Southeast Landfill Area due to natural attenuation processes. The estimated time to achieve remedial goals for VOCs in groundwater at the Site under the No-Action Alternative varies across the Site and ranges from zero years for the Southwest Area to approximately 42 years for the Southwest Landfill Area. The estimated time required for each of the six geographic areas to achieve remedial goals under the No Action Alternative is listed in Table 6-1.

Under the No Action Alternative, treated groundwater would no longer be discharged to Sinking Pond. This would eliminate some of the detrimental effects that the ARS discharge has had on the pond, such as turbidity of the surface water and continued addition of arsenic and phosphorus to the pond. No monitoring would be done to evaluate the impacts of this change on ecological receptors in the pond.

EVALUATION

The detailed analysis of the No Action Alternative against the seven NCP evaluation criteria is presented in Table 6-2.

COST

The estimated cost for the No Action Alternative is $0 as no further work at the site is assumed.

6.1.2 ALTERNATIVE GW-2: LIMITED ACTION

The detailed analysis for the Limited Action Alternative is presented below.

DESCRIPTION

The Limited Action Alternative would be applied to all six geographic areas of the Site and is intended to prevent direct contact with contaminated groundwater at the Site. It consists of shutting down the existing ARS, implementing institutional controls to control human exposure to contaminated water, and monitoring to evaluate the progress toward achieving remedial goals. The groundwater flow and transport model was used to estimate the time for VDC concentrations in groundwater to decrease to the remedial goal of 7 µg/L Site-wide and benzene concentrations to decrease to the remedial goal of 5 µg/L in the Southeast Landfill Area due to natural attenuation processes. The estimated time to achieve remedial goals for groundwater under this alternative is the same as the No Action Alternative and ranges from zero years for the Southwest Area to approximately 42 years for the Southwest Landfill Area. The estimated time required for each of the six geographic areas to achieve remedial goals under the Limited Action Alternative is listed in Table 6-1.

Under the Limited Action Alternative, treated groundwater would no longer be discharged to Sinking Pond. This would eliminate some of the detrimental effects that the ARS discharge has had on the pond, such as turbidity of the surface water and continued addition of arsenic and phosphorus to the pond. As part of this alternative, monitoring would be done to evaluate the impacts of this change on ecological receptors in the pond.

LONG-TERM MONITORING

Long term monitoring of groundwater would be performed to determine if the alternative is performing as expected and to monitor changes in groundwater concentrations over time.

For costing purposes it was assumed that the annual monitoring that is currently done would continue for a length of time equal to the model-calculated VOC-contaminated groundwater cleanup time in each geographic area, plus five years. Monitoring would actually continue until remedial goals are met for all compounds. It is likely that over time the scope and frequency of monitoring would change as conditions warrant. In addition, for the duration of the remedial action, data collected during the annual monitoring events would be further evaluated in five year reviews. The purpose of a Five-Year Review would be to assess potential impacts of contaminants remaining in groundwater and evaluate whether the remedial alternative remains protective of human health and the environment. If appropriate, additional actions may be implemented as a result of these reviews.

INSTITUTIONAL CONTROLS

Institutional controls would be implemented to restrict use of, and exposure to, contaminated groundwater throughout the duration of the remedial action. Institutional controls would remain in place in each geographic area of the Site until remedial goals were met. These controls would include restrictions on the installation of private wells in pre-determined areas. In addition, Grace would restrict the use of contaminated groundwater on its property. In the event that the Grace property is sold, appropriate restrictions would be included in any deeds.

EVALUATION

The detailed analysis of the Limited Action Alternative against the seven NCP evaluation criteria is presented in Table 6-3.

COST

The estimated present worth cost of Alternative GW-2 is $1,774,000. Costs are broken down into capital costs, monitoring costs, and O&M costs. Capital costs of $114,000 are associated with decommissioning of existing ARS extraction wells and implementation of institutional controls. There are no O&M costs associated with this alternative. The estimated present worth cost for long-term monitoring and reporting is approximately $1,660,000. The cost estimate for the Limited Action Alternative is based on the following assumptions:

- Current annual monitoring plus additional monitoring for inorganics would continue for a length of time equal to the model-calculated VOC cleanup time in each geographic area plus five years;
- A Site-wide water level measurement round would be made annually; and
- An annual report summarizing the monitoring data would be prepared every year, with a more detailed report prepared every five years.

Detailed cost information is included in Appendix C.

6.1.3 ALTERNATIVE GW-3: ACTIVE REMEDIATION

The detailed analysis for the Active Remediation Alternative is presented below.

DESCRIPTION

The Active Remediation Alternative for groundwater consists of groundwater extraction with ex-situ treatment and MNA. This alternative consists of groundwater extraction wells designed to capture groundwater in a specified area. Contaminated groundwater outside the capture zone would be remediated through natural attenuation processes. In all groundwater extraction scenarios evaluated, the fact that groundwater extraction and treatment has been operational over much of the Site for almost 20 years was indirectly incorporated into the model analyses. Groundwater from the extraction wells would be transported to a new treatment system via underground piping. Two options were considered for treatment system location. One option considered a centralized treatment system located near the Industrial Landfill for all extracted groundwater. The second option considered two separate treatment systems, one located near the Industrial Landfill, and a second treatment system located in the Northeast Area to treat water that was estimated to be extracted from the Northeast Area pumping scenarios. A single treatment system, located near the Industrial Landfill is the recommended option for this remedial alternative.

Based on the results of treatability testing done at the Site for inorganic compound removal and the historic operational performance of the current VOC removal technology, chemical precipitation for the removal of inorganic compounds and air stripping coupled with off-gas treatment using granular activated carbon (GAC) for the removal of VOCs would be used to treat the groundwater. The treated water would be discharged to Sinking Pond. Institutional controls would be implemented to restrict use of and exposure to contaminated groundwater throughout the duration of the remedial action. Groundwater monitoring would be done to evaluate the effectiveness of the remedy.

DEVELOPMENT OF CONCEPTUAL PUMPING SCENARIOS

The groundwater flow and contaminant transport model was used to evaluate numerous pumping scenarios throughout the Site in order to select components of the Active Remediation Alternative. Figure 6-1 shows the various pumping scenarios which were evaluated in order to develop a conceptual groundwater extraction system. A description of the various pumping scenarios is provided below. For each of these scenarios, groundwater beyond the capture zone would be remediated through natural attenuation processes.

FORMER LAGOON AREA

Two pumping scenarios were evaluated for the Former Lagoon Area. Under the first scenario, groundwater within the area labeled as Zone A on Figure 6-1 would be captured and treated by a single new extraction well pumping at a rate of approximately 45 gpm. For the second scenario, groundwater within the area labeled as Zone B on Figure 6-1 would be captured and treated by a series of five extraction wells (two existing ARS wells (NLBR-R, NLGP) and three new wells) pumping at a combined rate of approximately 100 gpm.

Analysis of the model results indicates that groundwater extraction under either pumping scenario would not reduce the time to reach the remedial goals for VOCs as compared to the Limited Action Alternative. Model analyses also indicate that the Assabet Public Water Supply wells will not become recontaminated as a result of cessation of pumping in the Former Lagoon Area.

The Draft RI Report (GeoTrans, 2005) identified groundwater in the southern portion of the Former Lagoon area as having relatively elevated arsenic concentrations with lower arsenic concentrations in groundwater north of the MBTA railroad tracks (Figures 1-7 and 1-8 of this FS Report). This pattern of arsenic concentrations in groundwater is consistent with the pattern one would expect in the transition from a reducing groundwater environment to an aerobic groundwater environment. Field measurements of oxidation reduction potential (ORP) during sampling indicate a mixed aerobic/anaerobic groundwater system beneath and downgradient of the Former Lagoon Area. Bedrock groundwater ORP values are negative indicating a reducing groundwater environment. Most of the unconsolidated deposits groundwater ORP concentrations are positive, indicating an aerobic environment. It is expected that, as MNA of the Former Lagoon Area progresses and VOC concentrations continue to decrease, the groundwater system will become more aerobic. Arsenic concentrations and mobility in groundwater will decrease in response to this change, and the potential to re-contaminate the North Lagoon Wetland sediments as a result of site-related contaminated groundwater will also decrease. Groundwater monitoring in the Former Lagoon Area will include periodic measurements of geochemical parameters, such as ORP, in addition to arsenic concentrations.

NORTHEAST AREA

Four different pumping scenarios were evaluated for the Northeast Area. Two of the pumping scenarios considered groundwater extraction with discharge of treated water to Sinking Pond, and two of the scenarios considered groundwater extraction with downgradient reinjection of the treated water. Figure 6-1 outlines the geographic areas of each of the four scenarios that were evaluated. The four scenarios are:

- Scenario 1 – Zone C capture with extracted water conveyed to a centralized treatment system with subsequent discharge to Sinking Pond;
- Scenario 2 – Zone D capture with extracted water conveyed to a centralized treatment system with subsequent discharge to Sinking Pond;
- Scenario 3 – Zone C capture with downgradient injection of treated water; and

- Scenario 4 – Zone J capture with downgradient injection of treated water.

Development of the pumping scenarios for the Northeast Area required consideration of two issues not present in other areas. One was consideration of the management of the extracted and treated groundwater. The other was consideration of the timeframe necessary for an extraction/injection system to be constructed and become operational. Each of these conditions is discussed briefly in the following paragraphs.

Under current conditions of natural attenuation, the contaminated groundwater in the Northeast Area flows toward and discharges to Fort Pond Brook and/or flows toward and is captured and treated at the School Street wellfield. Installation of extraction wells in the Northeast Area has the potential to reduce the rate of groundwater discharge to Fort Pond Brook and to lower water levels in the vicinity of the School Street wellfield. To off-set these potential impacts, the conceptual design evaluated for the Northeast Area included two scenarios that assumed that extracted groundwater would be re-injected to the aquifer in the Northeast Area instead of being discharged to Sinking Pond following treatment.

With very limited Grace owned land within the Northeast Area, extraction/injection system infrastructure would need to be located on privately-owned land, and access agreements would need to be obtained for the construction, operation, and monitoring of any extraction/injection system in the Northeast Area. For purposes of evaluating cleanup times for the Northeast Area, it was optimistically assumed that if an extraction/injection system were selected for the Northeast Area that it could be designed, approved by all interested parties, constructed and be operational by fall 2008. Fall 2008 is seven years after the fall 2001 data that are used as the baseline condition for the model analyses. Therefore, for all remedial scenarios considered for the Northeast Area, an initial 7-year long period of natural attenuation was assumed to occur prior to operation of any extraction/injection wells. Model-calculated time frames to reach groundwater cleanup goals for all scenarios include this 7-year period of natural attenuation. To put this assumption in a different context, by this fall there will already have been four years of natural attenuation of the Northeast Area since the fall 2001 baseline water quality sampling. The model calculations assume three additional years of natural attenuation would occur before an extraction/injection system could be operational in this area.

For purposes of comparing the different Northeast Area remedial pumping scenarios, the following information was tabulated:

- Time to reach MCLs for VDC (Table 6-4);
- Model-calculated groundwater discharge to Fort Pond Brook (Table 6-5);
- Model-calculated water levels near the School Street wellfield public supply wells (Table 6-6);
- Model-calculated VDC concentrations at each of the School Street wellfield public supply wells (Figures 6-2 through 6-4); and
- VDC volume remaining in the groundwater system versus time (Figure 6-5).

Each of the four pumping scenarios that were evaluated is described below.

Under Scenario 1, groundwater within the area labeled as Zone C on Figure 6-1 would be captured and treated by two extraction wells pumping at a rate of 90 gpm. Extracted groundwater would be conveyed to a centralized treatment system near the Industrial Landfill. The calculated time to reach MCLs in the Northeast Area groundwater is 36 years, including 7 years of natural attenuation prior to operation of the extraction wells. The model-calculated rate of groundwater discharge to Fort Pond Brook was reduced by about 40 percent compared to a natural attenuation remedy. Model calculations indicate that groundwater levels near the Christofferson and Scribner wells would be lowered on average by less than 0.5 feet, and groundwater levels at the Lawsbrook well would be lowered on average by about one foot under this pumping scenario. Model-calculated VDC concentrations at the Christofferson, Scribner, and Lawsbrook wells are shown in Figures 6-2 through 6-4. Model-calculated VDC volume remaining in the groundwater system versus time of remediation is shown on Figure 6-5. The estimated cost for this pumping scenario is about three million dollars plus the capital cost of the groundwater treatment system.

Under Scenario 2, groundwater within the area labeled as Zone D on Figure 6-1 would be captured and treated by seven extraction wells pumping at a combined rate of approximately 165 gpm. Extracted groundwater would be conveyed to a centralized treatment system near the Industrial Landfill. The calculated time to reach MCLs in the Northeast Area groundwater under this pumping scenario is 20 years, including 7 years of natural attenuation prior to operation of the extraction wells. The model-calculated rate of groundwater discharge to Fort Pond Brook was reduced by about 75 percent compared to a natural attenuation remedy. Model calculations indicate that groundwater levels would be lowered on average by less than 0.5 feet at the Christofferson well, by about one foot at the Scribner well, and by about 1.5 feet at the Lawsbrook well. Model-calculated VDC concentrations at the Christofferson, Scribner, and Lawsbrook wells are shown in Figures 6-2 through 6-4. Model-calculated VDC volume remaining in the groundwater system versus time of remediation is shown on Figure 6-5. The estimated cost for this pumping scenario is about 5.1 million dollars plus the capital cost of the groundwater treatment system.

Under Scenario 3, groundwater within the area labeled as Zone C on Figure 6-1 would be captured and treated by three extraction wells pumping at a combined rate of approximately 100 gpm. The treated water would be injected back into the ground using four injection wells at the outer edge of the capture zone. Extracted groundwater would either be conveyed to a centralized treatment system near the Industrial Landfill, or treated at a separate treatment system constructed in the Northeast Area. The calculated time to reach MCLs in the Northeast Area groundwater under this pumping scenario is 20 years, including 7 years of natural attenuation prior to operation of the extraction and injection wells. There was negligible change in the model-calculated rate of groundwater discharge to Fort Pond Brook, about 0.01 cfs as compared to the natural attenuation scenario. Model calculations indicate that there would be negligible change in groundwater levels near the Christofferson, Scribner, and Lawsbrook wells under this pumping scenario. Model-calculated VDC concentrations at the Christofferson, Scribner, and Lawsbrook wells are shown in Figures 6-2 through 6-4. Model-calculated VDC volume remaining in the groundwater system versus time of remediation is shown on Figure 6-5. The estimated cost for this pumping/injection scenario is about 3.7 million dollars plus the capital cost of the groundwater treatment system.

Under Scenario 4, groundwater within the area labeled as Zone J on Figure 6-1 would be captured and treated by eight extraction wells pumping at a combined rate of approximately 250 gpm. The treated water would be injected back into the ground using 12 injection wells at the outer edge of the capture zone. Extracted groundwater would either be conveyed to a centralized treatment system near the Industrial Landfill, or treated at a separate treatment system constructed in the Northeast Area. For this pumping scenario, the previous constraint to minimize to the extent possible the number of wells and amount of underground piping located on private residential property was relaxed. There were no constraints regarding the installation of wells or underground piping on private residential property. Consequently, many of the extraction and injection wells and much of the underground piping for water conveyance was located on private property. The calculated time to reach MCLs in the Northeast Area groundwater under this pumping scenario is 17 years, including 7 years of natural attenuation prior to operation of the extraction and injection wells. There was negligible change in the model-calculated rate of groundwater discharge to Fort Pond Brook, about 0.01 cfs as compared to the natural attenuation scenario. Model calculations indicate that average groundwater level changes near the Christofferson, Scribner, and Lawsbrook would be about one-half foot, or less. Model-calculated VDC concentrations at the Christofferson, Scribner, and Lawsbrook wells are shown in Figures 6-2 through 6-4. Model-calculated VDC volume remaining in the groundwater system versus time of remediation is shown on Figure 6-5. The estimated cost of this pumping/injection scenario is about 8 million dollars plus the capital cost of the groundwater treatment system.

Pumping scenarios 3 and 4, which include injection wells to return treated groundwater to the Northeast Area groundwater, were included in the evaluation for two primary reasons. One reason for considering reinjection of treated groundwater was to reduce the negative impact that groundwater extraction alone would have on the groundwater system. In other words, reinjection would offset the reduction in groundwater discharge to Fort Pond Brook and the reduction in groundwater levels near the School Street wellfield Public Water Supply wells that would result from conveying the extracted water to a centralized treatment system and discharging it to Sinking Pond. However, there are several potentially serious implementability restrictions regarding reinjection of treated groundwater to the Northeast Area. One is the additional inconvenience to residents in the Northeast Area. Reinjection of treated groundwater to the Northeast Area would require additional wells and underground piping be installed. Consequently, there would be greater likelihood that infrastructure related to the extraction/injection system would need to be located on private property or on town owned land adjacent to the private property. A second potentially serious implementability restriction regarding reinjection of treated water to the Northeast Area is the likelihood of biogeochemical changes causing well-fouling and/or aquifer clogging. The dissolved oxygen content and temperature of the extracted water will change as a result of aeration and other treatment. These changes increase the likelihood of well fouling and/or aquifer clogging due to biological growth and precipitation of inorganics, either at the injection well or in the aquifer. The former affects the viability of the injection well and the latter could potentially affect the School Street wellfield.

Based on concerns regarding the potential for increased concentrations of VDC reaching the School Street Wellfield, the model-calculated VDC concentrations at Christofferson, Lawsbrook, and Scribner wells under the current natural attenuation conditions and the four pumping scenarios evaluated for the Northeast Area are presented on Figures 6-2 through 6-4. Post-2000 observed VDC concentrations are also included on those figures. The model-calculated VDC concentrations under the existing natural attenuation conditions are a reasonably good representation of VDC concentrations that have been detected in these wells during the past four years. The maximum model-calculated VDC concentration of 15 μg/l at the Lawsbrook well, is substantially lower than the School Street wellfield treatment system is capable of removing. The School Street wellfield treatment system is able to remove VDC concentrations of approximately 600 μg/L (Layne Christensen Company, 2001).

Figure 6-5 shows the amount of VDC remaining in the groundwater system versus time of remediation for each of the four pumping scenarios evaluated as well as a natural attenuation scenario. The amount of VDC remaining in the groundwater system beneath the Northeast Area is estimated to be about 24 gallons. This includes VDC that is sorbed to the geologic matrix as well as VDC that is dissolved in groundwater. For all scenarios, the first seven years (from 2001 to 2008) is a period of natural attenuation, so the rate of mass removal from the groundwater system is identical for all scenarios during this time period. The graph indicates that more than half of the 24 gallons of VDC estimated to remain in the Northeast Area groundwater system would be removed during this seven year period. After seven years, the differential rate of VDC mass removal for the various pumping scenarios is illustrated by the five separate lines on the graph. The graph illustrates that there is very little difference in the amount of VDC remaining in the groundwater system for the various pumping scenarios compared to the natural attenuation scenario. At ten years, the maximum difference between the scenarios is about 2.5 gallons, at 15 years about 2 gallons, and at 20 years about 1 gallon.

Considering the implementation difficulties associated with groundwater extraction and treatment in this area, the minimal amount of VDC remaining in the groundwater system, the limited impact that treatment would have on both the mass removal of VDC and the time it would take to achieve PRGs, and the costs associated with the pumping scenarios, groundwater extraction and treatment in the Northeast Area is not included as a component of this remedial alternative. The MNA component of this remedial alternative is appropriate for the remaining cleanup of this area.

SOUTHWEST AREA

Groundwater extraction in the Southwest Area was not considered for the groundwater extraction system presented in this alternative. As shown in Table 2-9, little VOC contamination remains in the Southwest Area groundwater. Between September 1999 and June 2002, VDC was detected in groundwater at a concentration greater than the MCL of 7 μg/L in only three wells within the area, with a maximum concentration of 14 μg/L. Vinyl chloride was detected at a concentration greater than the MCL of 2 μg/L in only one well within the area, with a maximum concentration of 4.7 μg/L. Because prior active pumping along with natural processes has reduced contaminant concentrations to very low levels, the MNA component of this remedial alternative is appropriate for the remaining cleanup in this area of the Site.

ASSABET RIVER AREA

Only one pumping scenario was considered for the Assabet River Area, because the area of groundwater contamination is limited in size and the contaminated groundwater is located close to the Assabet River. Under the pumping scenario, groundwater within the area labeled on Figure 6-1 as Zone E would be captured and treated. The model calculations indicate that two new extraction wells pumping a total of approximately 30 gpm would provide capture of groundwater within Zone E. As indicated in Table 6-4, the groundwater flow and transport model indicates that remedial goals for VOCs in the Assabet River Area would be reached in approximately 17 years under this pumping scenario. This cleanup time is the same as the predicted cleanup time under the Limited Action Alternative. Moreover, given that current groundwater discharge to the Assabet River does not pose an unacceptable risk to human health or the environment (PHRA & BERA, Menzie-Cura, 2005a & b), active management of the groundwater contamination in this area is not necessary. Therefore, groundwater extraction in this area is not included as part of this remedial alternative. Prior active pumping along with natural processes has reduced contaminant concentrations to low levels and the time frame to meet cleanup levels is reasonable under the circumstances, therefore the MNA component of this remedial alternative is appropriate for the remaining cleanup in this area of the Site.

SOUTHWEST LANDFILL AREA

Two pumping scenarios were considered for the Southwest Landfill Area. Under the first scenario, groundwater within the area labeled on Figure 6-1 as Zone F would be captured and treated. The model indicates that two existing ARS wells (MLF and WLF) and one new extraction well pumping at a combined rate of approximately 85 gpm would provide capture of groundwater within Zone F. Under the second scenario, groundwater within the area labeled on Figure 6-1 as Zone G would be captured and treated. The model indicates that two existing ARS wells (MLF and WLF) and two new extraction wells pumping at a combined rate of approximately 100 gpm would provide capture of groundwater within Zone G.

As indicated in Table 6-4, a comparison of the two pumping scenarios indicates that VOC remediation goals would be reached at approximately the same time. However, the capture of groundwater within Zone F would be less costly. Both scenarios would limit the migration of contaminated groundwater to the Assabet River and prevent the area between the Industrial Landfill and the Assabet River, for which remedial goals have been achieved, from becoming re-contaminated. This alternative would reduce the time to achieve remedial goals from approximately 42 years under the Limited Action Alternative to approximately 23 years under the Zone F pumping scenario. For all of these reasons, groundwater extraction for Zone F is included as a component of this remedial alternative.

SOUTHEAST LANDFILL AREA

Two pumping scenarios were also considered for the Southeast Landfill Area. Under the first scenario, groundwater within the area labeled on Figure 6-1 as Zone H would be captured and treated. The model indicates that one existing ARS well (ELF) and one new extraction well pumping at a combined rate of approximately 20 gpm would provide capture of groundwater within Zone H. Under the second scenario, groundwater within the area labeled on Figure 6-1 as Zone I would be captured and treated. The model indicates that three new extraction wells pumping at a combined rate of approximately 35 gpm would provide capture of groundwater within Zone I. As indicated in Table 6-4, a comparison of the two pumping scenarios indicates that neither pumping scenario reduces clean-up times for VOC-contaminated groundwater as compared to the Limited Action Alternative.

Elevated arsenic concentrations are reported for groundwater samples from LF-06, B-08, LF-15, MLF and ELF. This group of wells is approximately coincident with the region of highest benzene concentrations in groundwater. Groundwater samples from these wells also have strongly negative ORP values, indicating anaerobic groundwater. Downgradient from the area of these wells, the ORP values are positive, indicating a change to aerobic groundwater conditions. In this area, arsenic concentrations are considerably lower. The ARS appears to be providing hydraulic containment of groundwater in the area with strongly negative ORP values and elevated arsenic concentrations. If hydraulic control of this area is lost, then downgradient migration of the anaerobic groundwater with subsequent mobilization of arsenic is possible. To prevent downgradient migration of the anaerobic groundwater and additional mobilization of arsenic, groundwater extraction to maintain hydraulic control of the area of wells LF-06, B-08, LF-15, MLF and ELF is included as a component of this remedial alternative.

GROUNDWATER EXTRACTION SYSTEM

Based on the modeling results and other considerations discussed above, the conceptual design of the active remediation alternative would consist of groundwater extraction wells installed to capture groundwater generally in the area outlined on Figure 6-6. Two of the existing ARS wells (MLF and WLF) would be included as part of a new groundwater extraction and treatment system. Two additional wells would be installed south of the Industrial Landfill. The model indicates that these four wells pumping a combined rate of approximately 90 gpm would provide capture of the area outlined on Figure 6-6.

The groundwater flow and transport model was used to estimate the time for VDC concentrations to decrease to the remedial goal of 7 µg/L site-wide and benzene concentrations to decrease to the remedial goal of 5 µg/L in the Southeast Landfill Area due to groundwater extraction and natural attenuation processes. The estimated times to achieve remedial goals for groundwater under this alternative ranges from zero years for the Southwest Area to approximately 26 years for the Northeast Area. The model-estimated clean-up time for each of the six geographic areas is listed in Table 6-7. The times for Alternative GW-3 differ slightly from those presented in Table 6-4 because the hydraulic gradients that result from this alternative, with pumping only downgradient of the Industrial Landfill, are slightly different from the hydraulic gradients that resulted from the simulations previously described in Section 6, in which pumping occurred in five of the geographic areas simultaneously.

As discussed in Appendix B, a sensitivity analysis was done to evaluate the range of VOC clean-up times that might be expected based on uncertainty in the values for retardation factor and decay rate that were used for the majority of the groundwater flow and contaminant transport simulations. While the retardation factor and decay rate that were used in the modeling are supported by Site data, there is some uncertainty in these values. As discussed in Appendix B, additional simulations were done for the Active Remediation Alternative in which

- the retardation factor was decreased to one;
- the decay rate was reduced to zero; and
- the retardation factor was reduced to one and the decay rates decreased to zero simultaneously.

The sensitivity analysis indicates that the Site-wide VOC clean-up time for the Active Remediation Alternative could vary between approximately 17 and 37 years.

GROUNDWATER TREATMENT SYSTEM

The location of the treatment system is assumed to be near the Industrial Landfill. This would consolidate most of the long-term remedy components in one geographic area. Chemical precipitation for the removal of inorganic compounds and air stripping coupled with off-gas treatment using granular activated carbon (GAC) for the removal of VOCs has been assumed to treat the groundwater. To ensure that the treatment plant has sufficient capacity to address any reasonable design changes, the capital cost assumed construction of a treatment plant capable of handling a flow of 200 gpm.

Bench-scale jar testing was done in December 2002 to evaluate the effectiveness of chemical precipitation at removing inorganic compounds from groundwater at the Site. The results were presented in the *Groundwater Treatability and Pilot Testing Evaluation Report* prepared by GeoTrans (2003). Results of the testing indicated that potassium permanganate was effective in removing iron, manganese, and arsenic from the groundwater that is extracted by the current system. The treatability testing also indicated that removal of these inorganic compounds in groundwater would be optimal if chemical precipitation were followed by filtration and if a portion of the removed solids were recycled. In addition, the test indicated that chemical precipitation was successful in removing phosphorous and in controlling odors.

The results of the treatability test were used to select an inorganics removal system consisting of an influent equalization tank and feed pumps, chemical precipitation system (flocculation/gravity settler/thickener), gravity sand filter and chemical feed systems using potassium permanganate and anionic polymer. Following precipitation of inorganic compounds, water would be pumped to the air stripper for VOC treatment.

For the treatment of VOCs in groundwater extracted from the Site, a shallow tray air stripper is proposed. Air would be forced into the air stripper via a blower to assure greater than 99% removal of VOCs in groundwater.

Following air stripping, the treated groundwater would be discharged to Sinking Pond at the location of the current ARS discharge. This would recharge the treated groundwater to the local aquifer where it would be available to the public water supply wells. Water from the treatment plant would be conveyed to the discharge area through underground piping. The inlet area would be redesigned to accommodate the new groundwater treatment system flow and to develop a less turbulent flow regime. This may consist of a widened inlet mouth and design of a flow dampening hydraulic control, such as an overflow weir. Air stripper off-gas would be directed into a GAC unit for odor control and removal of VOCs. It is expected that the initial VOC removal rate would be approximately 140 pounds per year.

Sludge generated from the chemical precipitation system would be collected in a sludge holding tank. The sludge would be dewatered periodically with a filter press. The sludge is likely to be non-hazardous (GeoTrans, 2003). Therefore, it was assumed that sludge would be disposed at an off-site landfill as a non-hazardous waste. Prior to initial disposal of sludge, sludge samples would be collected and tested to confirm whether or not this material should be handled as hazardous waste. Figure 6-7 is a process flow diagram of the groundwater treatment system.

Long-Term Monitoring

A long-term monitoring program would be developed during remedial design after the ROD is signed. The objectives of the monitoring program would be to:

- Monitor water levels to confirm that the planned groundwater capture zones are being achieved;
- Monitor groundwater quality within the capture zones to assess the effectiveness of the system on reducing contaminant concentrations in groundwater; and
- Monitor groundwater quality outside of the capture zones to monitor the progress of natural attenuation of groundwater contamination toward reaching remedial goals.

For costing purposes it was assumed that the annual monitoring that is currently done would continue for the length of time the model estimated for VOC clean-up in each geographic area plus five years. Monitoring would actually continue until remedial goals are met for all compounds. It is likely that over time, the scope and frequency of monitoring would change as conditions warrant. In addition, for the duration of the active groundwater treatment, data collected during the annual monitoring events would be further evaluated in five-year reviews. The reviews would assess potential impacts of contaminants remaining in groundwater and evaluate whether human health and the environment are protected by the remedial alternative. If appropriate, additional actions may be implemented or the monitoring schedule could be re-evaluated as a result of these reviews.

Under the Active Remediation Alternative, treated groundwater would continue to be discharged to Sinking Pond. However, the extracted water would be treated to remove inorganic compounds, including phosphorus. This would minimize the effects that the ARS discharge has been having on the pond, such as turbidity of the surface water and continued addition of arsenic and phosphorus to the pond. Treatment system discharge, and its effect on Sinking Pond environment, would be monitored as part of this remedial alternative.

Institutional Controls

Institutional controls would be implemented to restrict use of, and exposure to, contaminated groundwater through the duration of the remedial action. Institutional controls would remain in place in each geographic area of the Site until remedial goals are met. These controls would include restrictions on the installation of private wells in a predetermined area. In addition, Grace would restrict the use of contaminated groundwater on its property. In the event that the Grace property is sold, appropriate restrictions would be included in any deeds.

Evaluation

The detailed analysis of the Active Remediation Alternative against the seven NCP evaluation criteria is presented in Table 6-8.

Cost

The Active Remediation Alternative consists of:

- Modification and reconfiguration of the ARS;
- Construction of a new groundwater treatment system;
- Operation and maintenance of the groundwater extraction and treatment system;
- Long-term groundwater monitoring; and
- Institutional controls.

Costs are broken down into capital costs, monitoring costs, and O&M costs. Capital costs are assumed to be the direct and indirect costs incurred to develop, construct, and implement the remedial alternative. Monitoring costs are incurred to do annual sampling and reporting. O&M costs are costs incurred to evaluate and maintain the effectiveness of the extraction system after the remedy is constructed.

The cost estimate for the Active Remediation Alternative assumes the following:

- Installation of two new extraction wells
- Installation of new equipment in the two new and two existing extraction wells;
- Installation of new underground piping to carry the groundwater to the central groundwater treatment plant;
- Construction of a groundwater treatment system designed to treat up to 200 gpm of groundwater for VOCs and inorganics;
- O&M of the groundwater extraction wells and associated piping;
- O&M of the treatment system at a flowrate of 90 gpm, including labor for a qualified treatment plant operator for 4 hours a day for 23 years; and
- Monthly sampling for VOCs, inorganics, and phosphorus analyses of influent to, and effluent from the treatment system.

The estimated present worth cost of Alternative GW-3 is $7,536,000. The estimated capital costs are $2,651,000. The present worth for long-term monitoring is approximately $1,722,000. The present worth for O&M is approximately $3,163,000. These costs assume a five percent discount rate. Detailed cost information is included in Appendix C.

6.2 SEDIMENT

The detailed analysis of sediment alternatives is intended to provide sufficient information to select the appropriate remedial alternative for impacted sediments at the two targeted areas at the Site, Sinking Pond and the North Lagoon Wetland. The descriptions are intended to provide the conceptual design of each alternative and are used for cost estimating purposes only. Costs presented in this analysis are based on existing data and knowledge of the Site. The detailed analysis of alternatives for Sinking Pond is done in Section 6.2.1 and the detailed analysis of alternatives for the North Lagoon Wetland is done in Section 6.2.2.

6.2.1 SINKING POND

As summarized in Section 2.2.2.1, potential human health and ecological risks were identified due to arsenic in accessible sediment in Sinking Pond. In addition, elevated concentrations of arsenic and other metals (likely copper, iron, and manganese) in sediment are likely contributing to risks to benthic invertebrates. Specific criteria for attainment of PRGs are summarized in Table 2-11. The PRG for arsenic in sediment accessible to humans is 42 mg/kg. Sediment accessible to humans is defined as sediment that is consistently covered by two feet of surface water or less and where the ground slope is such that someone can stand or walk comfortably. These areas include the inlet to Sinking Pond and sediment located between an elevation of 144.5 feet NGVD (the maximum surface water elevation of Sinking Pond) and 138 feet NGVD (two feet below the minimum surface water elevation of Sinking Pond) within the areas labeled SPBK-1 and SPBK-2 on Figure 1-14. The remainder of the perimeter of the pond is not considered accessible to humans because the slope of the ground is too steep for someone to stand or walk comfortably for a long enough frequency/duration to result in risk.

With respect to environmental receptors, there are both short-term and long-term goals. The need to attain short-term goals would trigger remediation in specific areas. As discussed below, the remediation necessary to achieve the short-term goals is also expected to lead to attainment of the long-term goals.

The short-term PRGs for Sinking Pond sediment are dependent primarily on three parameters: depth below water surface, relative steepness of the pond bottom grade, and the potential cumulative impact of several select metals. In shallow-sloping subaqueous areas that are consistently covered by less than twelve feet of water, remediation is triggered when arsenic exceeds 730 mg/kg or when the four metals arsenic, copper, iron, and manganese all exceed their respective PEC or SEL (whichever is applicable). These areas include the inlet to Sinking Pond and sediment located between an elevation of 144.5 feet NGVD (the maximum surface water elevation of Sinking Pond) and 128 feet NGVD (twelve feet below the minimum surface water elevation of Sinking Pond) within the areas labeled SPBK-1 and SPBK-4 on Figure 1-14. In the steeply-sloping subaqueous areas that are consistently covered by less than twelve feet of water, the short-term goal is to identify areas with arsenic greater than 730 mg/kg and copper , iron, and manganese all exceed their PEC or SEL (whichever is applicable), and then to evaluate the need to remediate such areas based on risks, feasibility, and implementability. These areas include sediment between an elevation of 144.5 feet NGVD (the maximum surface water elevation of Sinking Pond) and 128 feet NGVD (twelve feet below the minimum surface water elevation of Sinking Pond) located within the Pond but outside of the areas labeled SPBK-1 and SPBK-4 on Figure 1-14.

The long-term PRGs for sediment in Sinking Pond is a trend toward the maximum background concentration of 42 mg/kg for arsenic in the top two-inches of sediment located between an elevation of 144.5 feet NGVD (the maximum surface water elevation of Sinking Pond) and 128 feet NGVD (twelve feet below the minimum surface water elevation of Sinking Pond). It is thought that attainment of the short-term goals through remediation will be sufficient to start a trend toward background concentrations, thus attaining the long-term goal.

For any alternative evaluated, except the No Action Alternative, existing sediment data would need to be supplemented with additional sampling. The areal and vertical extent of metals concentrations that pose potential risk would need to be more fully defined. During development of design criteria, a sampling and analysis program would be implemented to delineate areas to target for remediation. This program would include sample collection for analysis for the targeted compounds arsenic, copper, iron, and manganese, total solids, and other parameters that may affect either excavation or disposal. Assumptions regarding the areal and vertical extent of contamination, volume of contaminated sediment, and characteristics of sediment have been made for purposes of the detailed analysis of alternatives described below.

Two remedial alternatives for Sinking Pond sediment have been retained for detailed analysis. They are:

- Alternative SP-SED-1: No Action; and
- Alternative SP-SED-3: Active Remediation.

6.2.1.1 ALTERNATIVE SP-SED-1: NO ACTION

The No Action Alternative is included as a baseline for evaluating the other remedial alternatives.

Description

In accordance with the NCP and RI/FS Guidance (USEPA, 1988), the No Action Alternative was developed as a baseline with which to compare other remedial alternatives. This alternative represents the minimal effort that would be taken at this Site. Under this alternative no sediment removal or treatment would be conducted.

Evaluation

The detailed analysis of the No Action Alternative against the seven NCP evaluation criteria is presented in Table 6-9.

Cost

There are no costs associated with this alternative.

6.2.1.2 ALTERNATIVE SP-SED-3: ACTIVE REMEDIATION

This section presents the detailed analysis of Alternative SP-SED-3: Active Remediation.

DESCRIPTION

Alternative SP-SED-3 includes excavation of the sediments from the Sinking Pond inlet as well as removal and/or burial/capping of sediments from select portions of the Pond that are above the thermocline and considered to pose risk to either human health or to environmental receptors. Specific criteria for attainment of PRGs are discussed in greater detail in Section 2.2.2 and summarized in Table 2-11. The decision regarding whether to remove and/or bury/cap sediment within the Pond will be made during the design phase and will take into consideration implementability factors. It was assumed that maximum sediment removal depth would be no greater than one foot, throughout much of Sinking Pond, but may be as much as six feet in limited areas near the inlet. It has been further assumed that much of the pond sediments would be amenable to removal by pumping, with the exception of some sediments in the inlet area, which will be removed through excavation. Work within the pond would require construction of temporary floating docks, while access to the Sinking Pond area would require construction of temporary roads. Sediments would be excavated and moved by pumped pipeline or truck to a temporary staging area on the Grace property for dewatering, analysis for disposal waste profile characterization, and ultimately preparation for disposal. Pending confirmation through development of final design plans, it is currently assumed that the dewatering process can be conducted within the general location of the current inlet area. Off-site disposal of dewatered sediments is anticipated. Based on the results of the waste profile characterization, however, consideration would be given to on-Site burial/capping of recovered sediments.

The inlet and select pond excavation areas would require restoration in accordance with state and local performance standards. In the event that discharges of treated groundwater to the pond were to continue, the inlet would also be redesigned to provide more effective energy dissipation. The mouth from the inlet to the Pond would be widened, and a hydraulic control, such as an overflow weir, would be installed. The purpose of these steps is to provide increased retention time for settling of suspended particles before the treated groundwater is discharged to the Pond and to reduce the energy of the discharge into the Pond. During this construction period the area of the bank adjacent to the former Pump House would also be rehabilitated by a qualified restoration expert.

Removal of the sediments would implicate federal and state wetlands regulations. Care would have to be taken to ensure compliance with applicable performance standards.

ENVIRONMENTAL MONITORING

The purpose of the environmental monitoring program would be to evaluate the top two inches of sediment within the Sinking Pond inlet area and within the Pond located between an elevation of 144.5 feet NGVD (the maximum surface water elevation of Sinking Pond) and 128 feet NGVD (twelve feet below the minimum surface water elevation of Sinking Pond) for trends toward the maximum background concentration of 42 mg/kg for arsenic. As part of this program, samples would be collected periodically from select locations to assess changes in arsenic concentrations in the top two inches of sediments. It is anticipated that the frequency of the monitoring events would be adjusted based on past observations and known changes in Site use.

In addition, periodic site reviews would be conducted. Data collected during the environmental monitoring program would provide information for this review. The review would assess potential impacts of contaminants remaining in the Sinking Pond sediments and evaluate whether human health and the environment continue to be protected by the alternative. If appropriate, additional actions may be implemented as a result of these reviews.

ALTERNATIVE EVALUATION

The detailed analysis for Alternative SP-SED-3 against the NCP evaluation criteria is presented in Table 6-10.

COST

A cost estimate was prepared for Alternative SP-SED-3 to aid in the selection of a remedial alternative. The costing assumes:

- Full sediment removal with off-site disposal;
- A final dry weight of 1.2 tons per cubic yard of in-place sediment;
- The depth of sediment at inlet discharge point (SPBK-4) averages about 6 feet;
- The depth of sediments in shallow sloping areas (SPBK-1, SPBK-2, and SPBK-3) averages about 1 foot;
- The depth of sediments averages about 0.5 feet in all other targeted sub-aqueous areas where surface grade slopes steeply;
- Removal of 100% of the sediments in the inlet and SPBK-4;
- In areas SPBK-1, SPBK-2, and SPBK-3, assumes removal of about 50% of all sediments that are within two feet of the water surface, and 100% of sediments in those areas that are deeper than two feet below the water surface; and

- Assumes removal of 50% of subaqueous sediments above the thermocline in areas other than SPBK-1, SPBK-2, SPBK-3, and SPBK-4.

The total estimated present worth cost (at 5 percent for 30 years) of this alternative is $5,961,000. The capital costs were estimated to be $5,730,000. The present worth cost for implementing long term monitoring and maintenance and five year reviews was estimated to be $231,000. Detailed cost information is included in Appendix C.

6.2.2 NORTH LAGOON WETLAND

As summarized in Section 2.2.2.1, potential human health risks were identified from exposure to arsenic in accessible sediment in the North Lagoon Wetland. Risks to wildlife were identified from exposure to arsenic and manganese in sediment in the North Lagoon Wetland. Risks to benthic invertebrates are likely caused by elevated concentrations of arsenic and other metals (likely copper, iron, and manganese). The PRG for arsenic in sediment accessible to humans will be 28 mg/kg; and all sediment within this wetland will be considered to be accessible to humans. The arsenic PRG for protection of human health has been determined to be protective for wildlife and benthic invertebrates The PRG for manganese in sediment accessible to wildlife will be 2,030 mg/kg, as summarized in Table 2-12. All North Lagoon Wetland sediment within the top one foot is considered accessible to wildlife and benthic invertebrates.

For any proposed remedy, except the No Action Alternative, additional sediment data would be acquired to supplement the existing sediment data. For the following evaluations, it has been assumed that groundwater is no longer a continuing source of manganese and arsenic to the wetland.

Two remedial alternatives for the North Lagoon Wetland have been retained for detailed analysis. They are:

- Alternative NLW-SED-1: No Action; and
- Alternative NLW-SED-3: Active Remediation.

6.2.2.1 ALTERNATIVE NLW-SED-1: NO ACTION

The No Action Alternative is included as a baseline for evaluating the other remedial alternatives.

Description

In accordance with the NCP and RI/FS Guidance (USEPA, 1988), the No Action Alternative was developed as a baseline with which to evaluate other remedial alternatives. This alternative represents the minimal effort that would be taken at this Site. Under this alternative, no sediment removal or treatment would be conducted in the North Lagoon Wetland.

Alternative Evaluation

The detailed analysis of Alternative NLW-SED-1 against the seven NCP evaluation criteria is presented in Table 6-11.

Cost

There are no costs associated with this alternative.

6.2.2.2 ALTERNATIVE NLW-SED-3: ACTIVE REMEDIATION

This section presents detailed analysis of Alternative NLW-SED-3, Active Remediation.

Description

Alternative NLW-SED-3 would address sediments within the North Lagoon Wetland that pose risks to either human health or environmental receptors. Remediation may include excavation, off-site disposal, on-site disposal, and burial-in-place. This alternative requires excavation of at least a portion of the impacted sediments in the North Lagoon Wetland. It is anticipated that some excavation will be required in the portion of the North Lagoon Wetland sediments that reside within the 100-year flood plain of Fort Pond Brook. Consideration will be given to burial-in-place for North Lagoon Wetland sediments that reside outside of the 100-year flood plain. The location of the 100-year flood plain for Fort Pond Brook is shown on Figure 1-15. Both off-site and on-site disposal of dewatered wetland sediments will be considered, based on assessment of post-dewatering characteristics. Decisions regarding excavation/burial/capping and on- or off-Site disposal will be made during the design-phase and will take into consideration implementability factors as well as a functionality assessment of certain portions of the wetland.

It is assumed that maximum sediment removal depth would be no greater than one foot in most areas, and that much of the wetland area would either be removed or destroyed in the removal effort. Work within the wetland using heavy equipment would require either construction of temporary roads or load-distributing floating platforms from which to excavate. Sediments would be excavated and moved by truck to a temporary staging area on the Grace property for dewatering, analysis for disposal waste profile characterization, and ultimately preparation for disposal. Off-site disposal is anticipated, but based on the results of the waste profile characterization, consideration would be given to on-site burial/capping of recovered sediments.

The wetland would require complete restoration in accordance with industry standards, including proper sediment restoration planning, planting plans, long term monitoring for success of revegetated areas, and follow up construction work as warranted by the relative success of the replicated wetland. It is not certain that such extensive excavation could comply with applicable performance standards, given the varied success rate of wetland restoration projects.

Environmental Monitoring

The purpose of the environmental monitoring program would be to assess the success of the restored wetland and to evaluate the North Lagoon Wetland area for signs of re-deposition of significant concentrations of arsenic and manganese. As part of this program, sediment samples would be collected periodically for analysis for arsenic and manganese, as well as other parameters that may facilitate dissolution and re-deposition, if warranted. It is anticipated that the frequency of the monitoring events would be adjusted based on previous observations and known changes in Site use.

In addition, periodic site reviews would be conducted. Data collected during the environmental monitoring program would provide information for this review. The review would primarily assess restoration of the North Lagoon Wetland, but would also evaluate whether human health and the environment continue to be protected by the alternative. If appropriate, additional actions may be implemented as a result of these reviews.

Alternative Evaluation

The detailed analysis for Alternative NLW-SED-3 against the seven NCP criteria is presented in Table 6-12.

Cost

A cost estimate was prepared for Alternative NLW-SED-3 to aid in the selection of a remedial alternative. The costing assumes:

- Full sediment removal with off-Site disposal;
- Excavation of sediment within the wetland to a depth of one foot; and
- Complete restoration of the wetland.

The total estimated present worth (at 5 percent for 20 years) of this alternative is $3,445,000. The capital costs for excavation and disposal of sediments from, and restoration of the North Lagoon Wetland was estimated to be $3,382,000. The present worth cost for implementing long term monitoring and maintenance was estimated to be $62,000. Detailed cost information is included in Appendix C.

7 COMPARATIVE ANALYSIS OF ALTERNATIVES

The comparative analysis of alternatives compares the three groundwater remedial action alternatives, the two sediment remedial action alternatives for Sinking Pond and the two sediment remedial action alternatives for the North Lagoon Wetland evaluated in Section 6 relative to the seven evaluation criteria used for the detailed analysis of alternatives. The purpose of the comparative analysis is to identify the advantages and disadvantages of each of the alternatives relative to one another and to aid in the selection of remedial alternatives for groundwater and for sediment at the Site.

As set forth in the NCP, specific CERCLA requirements are considered in comparing alternative remedies. To the extent practicable, the NCP requires that the selected alternative(s) should:

- Be protective of human health and the environment;
- Comply with ARARs;
- Offer short- and long-term effectiveness and permanence;
- Be implementable;
- Reduce toxicity, mobility, or volume as a principal element; and
- Be cost-effective.

In accordance with the approach outlined in the NCP for performing the comparative analysis of alternatives, the remedy selected for the Site must reflect the scope and purpose of the actions being undertaken and how these actions relate to other remedial actions and the long term-response at the Site. The identification of the preferred alternative and the final remedy selection are based on consideration of the major trade-offs among the alternatives in terms of the nine evaluation criteria. USEPA has categorized the evaluation criteria into three groups:

- Threshold criteria;
- Balancing criteria; and
- Modifying criteria.

A discussion of these criteria groups follows.

Threshold Criteria

The selected remedy must be protective of human health and the environment and comply with ARARs. Therefore, the USEPA has designated overall protection of human health and the environment and compliance with ARARs as the two threshold criteria. Absent an appropriate case for a waiver of some ARAR, an alternative must meet both criteria to be eligible for selection as the Site remedy.

Primary Balancing Criteria

The five primary balancing criteria are:

- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, or volume through treatment;
- Short-term effectiveness;
- Implementability; and
- Cost.

This balancing provides a preliminary assessment of the maximum extent to which permanent solutions and treatment can be used practicably in a cost-effective manner. The alternative that is protective of human health and the environment, complies with ARARs, and affords the most favorable balancing criteria is identified as the preferred alternative.

Modifying Criteria

State and community acceptance are factored into a final evaluation that determines which remedial alternatives are acceptable for the Site. As stated at the beginning of Section 6 of this report, state and community acceptance will be addressed in the ROD after public comments on the RI/FS and proposed plan have been received.

Section 7.1 presents the comparative analysis of the remedial alternatives for groundwater. Section 7.2 presents the comparative analysis of remedial alternatives for sediment.

7.1 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR GROUNDWATER

Table 7-1 presents the comparative analysis for the three remedial alternatives for groundwater that were evaluated in Section 6. The comparative analysis highlights the results of the detailed analysis and is summarized below.

Overall Protection of Human Health and the Environment

Alternative GW-1, No Action, would be the least protective of the three alternatives. It would offer no protection to human health and the environment. Potential risks from exposure to contaminated groundwater would remain. While natural attenuation processes would reduce contaminant concentrations in groundwater to remedial goals, no monitoring would be done to indicate when they are met.

Alternative GW-2, Limited Action, would provide greater protection than Alternative GW-1 because institutional controls would be implemented to restrict the use of contaminated groundwater. In addition, long-term groundwater monitoring would be done to verify the continued protection of human health and the environment, identify the then-current distribution of contamination, and document the progress toward reaching remedial goals. The time to reach remedial goals Site-wide is estimated to be 42 years, and would be the same under Alternative GW-1 or GW-2. The combination of institutional controls and natural attenuation is considered to be protective of human health and the environment.

Alternative GW-3, Active Remediation, would also be protective of human health and the environment. Similar to Alternative GW-2, institutional controls would be implemented to restrict the use of contaminated groundwater and long-term groundwater monitoring would be done to verify the continued protection of human health and the environment, identify the then-current distribution of contamination, and document the progress toward reaching remedial goals. Groundwater extraction with ex-situ treatment would decrease the time to reach remedial goals Site-wide to 26 years and is therefore more protective than Alternative GW-2.

Compliance with ARARs

Each of the alternatives would attain remedial goals in the long term. Alternative GW-3 would attain ARARs more quickly than Alternatives GW-1 and GW-2. It is expected that the discharge from an active treatment system would meet water-quality-related ARARs.

Long-term Effectiveness and Permanence

Alternative GW-1 would provide the least long-term effectiveness because there would be no controls to limit access to contaminated groundwater. Alternative GW-2 would be more effective than Alternative GW-1 because institutional controls would be implemented to limit access to contaminated groundwater. Alternative GW-3 is the most effective alternative in the long-term because, in addition to limiting access to contaminated groundwater, it would manage the migration of contaminated groundwater within some portions of the aquifer. All three alternatives would permanently reduce contaminant concentrations to remedial goals.

Reduction of Toxicity, Mobility, or Volume

All three alternatives would reduce toxicity and volume of contamination through natural attenuation processes. Alternative GW-3, however, also provides active containment and treatment of contaminated groundwater, which would reduce the mobility, volume, and toxicity of contaminants in some portions of the aquifer.

Short-Term Effectiveness

Under Alternatives GW-1 and GW-2, the existing groundwater extraction system (the ARS) would be shut down, without being replaced by another active treatment system. As a result, there may be some short-term impacts. Under Alternative GW-3, portions of the existing groundwater extraction system would be shut down, which could result in some short-term impacts. However, under Alternatives GW-2 and GW-3, monitoring would be done to assess the distribution of groundwater contamination. If monitoring data indicate that human health and the environment are not protected by either remedial alternative, additional actions could be implemented.

Under Alternative GW-3, discharge of treated groundwater to Sinking Pond may have some environmental impacts on the Pond. As a result of the proposed modifications to the water treatment system, any environmental impacts would be significantly less than currently exist. Construction and operation of the groundwater extraction system would not have significant impacts on the local community or Site workers.

Implementability

Alternative GW-1 could be readily implemented. The institutional controls required for either Alternative GW-2 or Alternative GW-3 may be difficult to implement. The groundwater extraction and treatment planned under Alternative GW-3 is a frequently used and effective remedial alternative. All aspects of the proposed extraction and treatment system are standard. Alternative GW-3 would require long-term maintenance to remain effective.

Cost

Alternative GW-1 is the least costly. Alternative GW-2 is more expensive than Alternative GW-1. Alternative GW-3 is the most costly.

7.2 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR SEDIMENT

Table 7-2 presents the comparative analysis of the two remedial alternatives for sediments in Sinking Pond and Table 7-3 presents the comparative analysis of the two remedial alternatives for sediments in the North Lagoon Wetland that were evaluated in Section 6. The comparative analyses, which highlight the results of the detailed analyses, are summarized in Section 7.2.1 for Sinking Pond and Section 7.2.2 for the North Lagoon Wetland.

7.2.1 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR SINKING POND SEDIMENTS

Overall Protection of Human Health and the Environment

Alternative SP-SED-1, No Action, would be the least protective of the two Sinking Pond sediment alternatives. It would offer no protection to human health and the environment. Potential risks from exposure to contaminated sediments would remain. While natural attenuation processes might reduce contaminant concentrations in sediments to remedial goals, no monitoring would be done to indicate whether or when they are met.

Alternative SP-SED-3, Active Remediation, comprises active remediation, either through excavation, burial/capping, or some combination, in such a way that would be protective of human health and the environment. Institutional controls would be required in the form of a deed restriction if the final plan incorporates burial/capping of impacted sediments as part of the remediation strategy. For any active remediation plan, short-term remedial goals are reached essentially at the close of construction activities and the attainment of long-term goals would be evaluated through monitoring.

Compliance with ARARs

Given that the No Action Alternative (SP-SED-1) relies entirely on what would be considered natural attenuation (redistribution, dilution, and natural burial), it would take the longest and least certain path toward reaching remedial goals. SP-SED-3, Active Remediation, that comprises full remediation, either through removal or burial/capping, achieves short-term remedial goals upon completion of construction activities. However, the active remedial alternative would have to comply with wetlands performance standards that would not be applicable to the No Action Alternative.

Long-term Effectiveness and Permanence

Alternative SP-SED-1, No Action, would provide the least long-term effectiveness, and because it does not include access restrictions of any type, it is the least permanent option.

Alternative SP-SED-3, Active Remediation, provides the greatest level of long-term effectiveness and permanence by virtue of having impacted sediments removed from the areas of concern or made inaccessible to sensitive receptors by burial/capping.

Reduction of Toxicity, Mobility, or Volume

Given that the No Action Alternative (SP-SED-1) relies entirely on what would be considered natural attenuation (redistribution, dilution, and natural burial) it would provide little to no reduction in toxicity, mobility, or volume.

The alternative that incorporates removal of sediments that pose risk, SP-SED-3, Active Remediation, provides the greatest level of reduction in toxicity, mobility, and volume. To the extent that some of the target sediments within the pond may be buried/capped under this alternative, those areas would experience only partial reduction in volume, and no reduction in toxicity; however, there will be some reduction in potential mobility by virtue of having sediments no longer exposed to surface activities.

Short-Term Effectiveness

The No Action alternative (SP-SED-1) provides very little change in short-term effectiveness. The Active Remediation Alternative, SP-SED-3, would provide much more immediate short term effectiveness. Normal construction-related access prohibitions and health and safety plans would be in place during construction activities, and should provide sufficient protection to the community, the workers, and the environment.

Implementability

The technology for the two alternatives is commonly used and readily available. The primary site constraints applicable to work in the Sinking Pond area are that work in and around wetlands and pond is cumbersome and arduous. The most challenging technical issues involve removal of sub-aqueous sediments (SP-SED-3) and restoration of the inlet area. However, all of the alternatives are reasonably implementable.

Cost

The No Action alternative (SP-SED-1) is the least costly alternative and SP-SED-3, Active Remediation, is the most costly.

7.2.2 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR NORTH LAGOON WETLAND

Overall Protection of Human Health and the Environment

Alternative NLW-SED-1, No Action, would be the least protective of the two North Lagoon Wetland alternatives. It would offer no protection to human health and the environment. Potential risks from exposure to contaminated sediments would remain. While natural attenuation processes might reduce contaminant concentrations in sediments to remedial goals, no monitoring would be done to indicate whether or when they are met.

Alternative, NLW-SED-3, Active Remediation, comprises active remediation through excavation in such a way that would also be protective of human health and the environment. Remedial goals are reached essentially at the close of construction activities.

Compliance with ARARs

Given that the No Action alternative (NLW-SED-1) relies entirely on what would be considered natural attenuation (redistribution, dilution, and natural burial), it would take the longest and least certain path toward reaching remedial goals. The alternative that comprises full remediation, through removal and/or partial burial/capping (NLW-SED-3, Active Remediation) achieves remedial goals upon completion of construction activities.

Alternative NLW-SED-3 involves active remediation and would have to comply with wetlands-related performance standards. NLW-SED-3 requires replacement of potions the North Lagoon Wetland and may have difficulty in complying with wetlands-related ARARs.

Long-term Effectiveness and Permanence

Alternative NLW-SED-1, No Action, would provide the least long-term effectiveness, and because it does not include access restrictions of any type, it is the least permanent of the four alternatives.

The alternative that incorporates removal or isolation of all sediments that pose risk to humans and the environment, NLW-SED-3, Active Remediation, provides the greatest level of long-term effectiveness and permanence by virtue of having all impacted sediments removed from the area of concern or made inaccessible to sensitive receptors by burial/capping. Alternatives NLW-SED-3 has some uncertainty regarding long-term reliability of any necessary wetlands restoration/replacement.

Reduction of Toxicity, Mobility, or Volume

Given that the No Action Alternative (NLW-SED-1) relies entirely on what would be considered natural attenuation (redistribution, dilution, and natural burial), it would provide little to no reduction in toxicity, mobility, or volume.

The alternative that incorporates removal or isolation of all sediments that pose risk to humans and the environment, NLW-SED-3, Active Remediation, provides the greatest level of reduction in toxicity, mobility, and volume.

Short-Term Effectiveness

The No Action Alternative (NLW-SED-1) provides very little change in short-term effectiveness. The remaining alternative includes active site remediation activities, and therefore provides a much greater measure of short term effectiveness. Normal construction-related access prohibitions and health and safety plans would be in place during construction activities, and should provide sufficient protection to the community, the workers, and the environment.

Implementability

The technology for both of the alternatives is commonly used and readily available. The primary site constraint applicable to work in the North Lagoon Wetland area is that work in and around wetlands is cumbersome and arduous. The most challenging technical issue is wetland restoration (NLW-SED-3) which historically has varied success rates.

Cost

The No Action alternative (NLW-SED-1) is the least costly alternative. The remaining alternative, NLW-SED-3, is the most costly.

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APPENDIX A

REMEDIAL GOALS

APPENDIX B

GROUNDWATER FLOW AND CONTAMINANT TRANSPORT MODEL

APPENDIX C

BASIS OF COST FOR EACH ALTERNATIVE INCLUDED IN THE DETAILED ANALYSIS

GROUNDWATER COSTING BACKUP

SEDIMENT COSTING BACKUP

TABLES

FIGURES

Table 2-7 Groundwater Preliminary Remediation Goals

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Tap Water

Exposure Point	CAS Number	Chemical (1)	Units	Cancer Class (2)	Target Endpoint (3)	Selected PRG (4)	Basis of PRG	Carcinogenic Risk (5,6)	Non-Cancer HI (5)
Assabet River Area	71-43-2	Benzene	µg/L	A	Hematological, Immunological	5	MCL (9)	1.03E-05	0.25
	75-35-4	1,1-Dichloroethene	µg/L	C	Hepatic	7	MCL (9)		0.028
	75-01-4	Vinyl Chloride (7)	µg/L	A	Hepatic	2	MCL (9)	3.53E-04	0.128
	7440-38-2	Arsenic	µg/L	A	Integumental, Cardiovascular	10	MCL (9)	2.64E-04	3.2
	7439-96-5	Manganese	µg/L	D	Neurological	844	Maximum Background (8)		3.4
							Total Cancer Risk =	6.27E-04	
							Sum of HI - Target Endpoint		
								Hepatic	0.156
Former Lagoon Area	71-43-2	Benzene	µg/L	A	Hematological, Immunological	5	MCL (9)	1.03E-05	0.25
	75-35-4	1,1-Dichloroethene	µg/L	C	Hepatic	7	MCL (9)		0.028
	75-01-4	Vinyl Chloride (7)	µg/L	A	Hepatic	2	MCL (9)	3.53E-04	0.128
	7440-38-2	Arsenic	µg/L	A	Integumental, Cardiovascular	10	MCL (9)	2.64E-04	3.2
	7439-96-5	Manganese	µg/L	D	Neurological	844	Maximum Background (8)		3.4
							Total Cancer Risk =	6.27E-04	
							Sum of HI - Target Endpoint		
								Hepatic	0.156
Southeast Landfill Area	71-43-2	Benzene	µg/L	A	Hematological, Immunological	5	MCL (9)	1.03E-05	0.25
	75-35-4	1,1-Dichloroethene	µg/L	C	Hepatic	7	MCL (9)		0.028
	107-06-2	1,2-Dichloroethane	µg/L	B2	Renal	5	MCL (9)	1.60E-05	0.048
	78-87-5	1,2-Dichloropropane	µg/L	B2	Renal	5	MCL (9)		0.048
	75-09-2	Methylene Chloride	µg/L	B2	Hepatic	5	MCL (9)	1.32E-06	0.0160
	75-01-4	Vinyl Chloride (7)	µg/L	A	Hepatic	2	MCL (9)	3.53E-04	0.128
	117-81-7	bis (2-ethylhexyl) phthalate	µg/L	B2	Hepatic	6	MCL (9)	3.62E-06	0.061
	7440-38-2	Arsenic	µg/L	A	Integumental, Cardiovascular	10	MCL (9)	2.64E-04	3.2
	7439-96-5	Manganese	µg/L	D	Neurological	844	Maximum Background (8)		3.4
							Total Cancer Risk =	6.48E-04	
							Sum of HI - Target Endpoint		
								Hepatic	0.233
								Renal	0.096

Table 2-7 Groundwater Preliminary Remediation Goals

Scenario Timeframe: Future	
Medium: Groundwater	
Exposure Medium: Tap Water	

Exposure Point	CAS Number	Chemical (1)	Units	Cancer Class (2)	Target Endpoint (3)	Selected PRG (4)	Basis of PRG	Carcinogenic Risk (5,6)	Non-Cancer HI (5)
Southwest Landfill Area	71-43-2	Benzene	µg/L	A	Hematological, Immunological	5	MCL (9)	1.03E-05	0.25
	75-35-4	1,1-Dichloroethene	µg/L	C	Hepatic	7	MCL (9)		0.028
	75-01-4	Vinyl Chloride(7)	µg/L	A	Hepatic	2	MCL (9)	3.53E-04	0.128
	7440-38-2	Arsenic	µg/L	A	Integumental, Cardiovascular	10	MCL (9)	2.64E-04	3.2
	7439-96-5	Manganese	µg/L	D	Neurological	844	Maximum Background(8)		3.4
							Total Cancer Risk =	6.27E-04	
							Sum of HI - Target Endpoint		
								Hepatic	0.156
Northeast Area	71-43-2	Benzene	µg/L	A	Hematological, Immunological	5	MCL (9)	1.03E-05	0.25
	75-35-4	1,1-Dichloroethene	µg/L	C	Hepatic	7	MCL (9)		0.028
	75-01-4	Vinyl Chloride(7)	µg/L	A	Hepatic	2	MCL (9)	3.53E-04	0.128
	7440-38-2	Arsenic	µg/L	A	Integumental, Cardiovascular	10	MCL (9)	2.64E-04	3.2
	7439-96-5	Manganese	µg/L	D	Neurological	844	Maximum Background(8)		3.4
							Total Cancer Risk =	6.27E-04	
							Sum of HI - Target Endpoint		
								Hepatic	0.156
Southwest Area	75-35-4	1,1-Dichloroethene	µg/L	C	Hepatic	7	MCL (9)		0.028
	75-01-4	Vinyl Chloride(7)	µg/L	A	Hepatic	2	MCL (9)	3.53E-04	0.128
	7440-38-2	Arsenic	µg/L	A	Integumental, Cardiovascular	10	MCL (9)	2.64E-04	3.2
	7439-96-5	Manganese	µg/L	D	Neurological	844	Maximum Background(8)		3.4
							Total Cancer Risk =	6.17E-04	
							Sum of HI - Target Endpoint		
								Hepatic	0.156

Notes:

(1) Chemicals listed are those that have a cancer risk greater than 10^{-6}, where the cumulative risk is greater than 10^{-4}, and/or where the target organ specific HI>1. All chemicals shown on this table have maximum concentrations exceeding the applicable ARAR.

(2) Cancer Class based on information provided in the Integrated Risk Information System (IRIS) on-line database.

(3) Target Endpoint based on information provided in the Integrated Risk Information System (IRIS) on-line database.

(4) PRGs are the minimum ARAR except for manganese (see note 8).

(5) Carcinogenic risk and/or non-carcinogenic hazard (HI) associated with the selected PRG.

(6) Carcinogenic risk is the sum of the adult and child carcinogenic risk (including ingestion, inhalation and dermal contact)

(7) Vinyl chloride cancer risk value is derived from methods outlined in USEPA 2000 *Draft Toxicological Review of Vinyl Chloride (in Support of Summary Information Provided on the Integrated Risk Information System)*

(8) Government Parties have agreed that the target PRG for manganese will be consistent with maximum background.

(9) MCLs = Federal Maximum Contaminant Levels for drinking water (http://www.epa.gov/safewater/mcl.html)

Table 2-8. Summary of Human Health Risks from Exposure to Groundwater.

Exposure Point	Exposure Medium	Chemical	Adult								Child								Sum of Adult and Child			
			Cancer Risk				Non-Cancer Hazard Quotient				Cancer Risk				Non-Cancer Hazard Quotient				Cancer Risk			
			Ingestion	Dermal	Inhalation	Exposure Routes Total	Ingestion	Dermal	Inhalation	Exposure Routes Total	Ingestion	Dermal	Inhalation	Exposure Routes Total	Ingestion	Dermal	Inhalation	Exposure Routes Total	Ingestion	Dermal	Inhalation	Total
Assabet River Area	Tap Water	Benzene	8E-06	1E-06	8E-06	2E-05	1E-01	2E-02	1E-01	2E-01	7E-06	7E-07	7E-06	2E-05	4E-01	4E-02	4E-01	8E-01	2E-05	2E-06	2E-05	3E-05
		Vinyl Chloride	7E-04	—	7E-04	1E-03	9E-01	—	9E-01	2E+00	8E-03	—	8E-03	2E-02	3E+00	—	3E+00	6E+00	8E-03	—	8E-03	2E-02
		Arsenic	4E-04	—	—	4E-04	3E+00	—	—	3E+00	4E-04	—	—	4E-04	9E+00	—	—	9E+00	8E-04	—	—	8E-04
		Manganese	—	—	—	—	3E+00	—	—	3E+00	—	—	—	—	1E+01	—	—	1E+01	—	—	—	—
	Irrigation Water	Vinyl Chloride	2E-06	7E-06	—	1E-05	3E-03	1E-02	—	1E-02	5E-04	4E-04	—	9E-04	4E-02	3E-02	—	7E-02	5E-04	4E-04	—	9E-04
		Arsenic	2E-06	5E-07	—	2E-06	1E-02	4E-03	—	1E-02	4E-06	6E-07	—	5E-06	1E-01	2E-02	—	1E-01	6E-06	1E-06	—	7E-06
Former Lagoon Area	Tap Water	Benzene	2E-05	3E-06	2E-05	4E-05	3E-01	4E-02	3E-01	6E-01	2E-05	2E-06	2E-05	4E-05	1E+00	1E-01	1E+00	2E+00	4E-05	5E-06	4E-05	8E-05
		Vinyl Chloride	1E-04	—	1E-04	2E-04	1E-01	—	1E-01	3E-01	1E-03	—	1E-03	2E-03	5E-01	—	5E-01	9E-01	1E-03	—	1E-03	3E-03
		Arsenic	8E-03	—	—	8E-03	5E+01	—	—	5E+01	7E-03	—	—	7E-03	2E+02	—	—	2E+02	1E-02	—	—	1E-02
		Manganese	—	—	—	—	6E+00	—	—	6E+00	—	—	—	—	2E+01	—	—	2E+01	—	—	—	—
	Irrigation Water	Vinyl Chloride	4E-07	1E-06	—	2E-06	5E-04	1E-03	—	2E-03	7E-05	7E-05	—	1E-04	6E-03	5E-03	—	1E-02	7E-05	7E-05	—	1E-04
		Arsenic	3E-05	1E-05	—	4E-05	2E-01	7E-02	—	2E-01	8E-05	1E-05	—	9E-05	2E+00	3E-01	—	2E+00	1E-04	2E-05	—	1E-04
Northeast Area	Tap Water	Benzene	3E-06	4E-07	3E-06	6E-06	4E-02	5E-03	4E-02	8E-02	2E-06	2E-07	2E-06	5E-06	1E-01	1E-02	1E-01	3E-01	5E-06	6E-07	5E-06	1E-05
		Vinyl Chloride	1E-04	—	1E-04	3E-04	2E-01	—	2E-01	3E-01	2E-03	—	2E-03	3E-03	6E-01	—	6E-01	1E+00	2E-03	—	2E-03	3E-03
		Arsenic	6E-04	—	—	6E-04	4E+00	—	—	4E+00	6E-04	—	—	6E-04	1E+01	—	—	1E+01	1E-03	—	—	1E-03
		Manganese	—	—	—	—	1E+00	—	—	1E+00	—	—	—	—	5E+00	—	—	5E+00	—	—	—	—
	Irrigation Water	Vinyl Chloride	5E-07	1E-06	—	2E-06	6E-04	2E-03	—	3E-03	1E-04	9E-05	—	2E-04	8E-03	7E-03	—	1E-02	1E-04	9E-05	—	2E-04
		Arsenic	2E-06	9E-07	—	3E-06	2E-02	8E-03	—	2E-02	7E-06	9E-07	—	8E-06	2E-01	2E-02	—	2E-01	9E-06	2E-06	—	1E-05
Southeast Landfill Area	Tap Water	Benzene	2E-03	3E-04	2E-03	5E-03	3E+01	5E+00	3E+01	6E+01	2E-03	2E-04	2E-03	4E-03	1E+02	1E+01	1E+02	2E+02	4E-03	5E-04	4E-03	9E-03
		1,2-Dichloroethane	7E-05	—	7E-05	1E-04	1E-01	—	1E-01	2E-01	6E-05	—	6E-05	1E-04	4E-01	—	4E-01	8E-01	1E-04	—	1E-04	3E-04
		1,2-Dichloropropane	4E-05	—	4E-05	8E-05	9E-02	—	9E-02	2E-01	4E-05	—	4E-05	7E-05	3E-01	—	3E-01	6E-01	8E-05	—	8E-05	2E-04
		Methylene Chloride	6E-06	—	6E-06	1E-05	4E-02	—	4E-02	7E-02	5E-06	—	5E-06	1E-05	1E-01	—	1E-01	3E-01	1E-05	—	1E-05	2E-05
		Vinyl Chloride	5E-04	—	5E-04	1E-03	6E-01	—	6E-01	1E+00	6E-03	—	6E-03	1E-02	2E+00	—	2E+00	5E+00	6E-03	—	6E-03	1E-02
		bis(2-Ethylhexyl)phthalate	1E-06	2E-06	—	3E-06	1E-02	2E-02	—	3E-02	9E-07	1E-06	—	2E-06	4E-02	4E-02	—	8E-02	2E-06	3E-06	—	5E-06
		Arsenic	2E-02	—	—	2E-02	1E+02	—	—	1E+02	2E-02	—	—	2E-02	4E+02	—	—	4E+02	3E-02	—	—	3E-02
		Manganese	—	—	—	—	1E+01	—	—	1E+01	—	—	—	—	5E+01	—	—	5E+01	—	—	—	—
	Irrigation Water	Benzene	8E-06	7E-05	—	8E-05	1E-01	9E-01	—	1E+00	2E-05	6E-05	—	8E-05	1E+00	3E+00	—	4E+00	3E-05	1E-04	—	2E-04
		1,2-Dichloroethane	3E-07	7E-07	—	1E-06	4E-04	1E-03	—	2E-03	8E-07	6E-07	—	1E-06	5E-03	4E-03	—	9E-03	1E-06	1E-06	—	2E-06
		1,2-Dichloropropane	1E-07	8E-07	—	9E-07	3E-04	2E-03	—	2E-03	4E-07	7E-07	—	1E-06	4E-03	6E-03	—	9E-03	6E-07	1E-06	—	2E-06
		Vinyl Chloride	2E-06	6E-06	—	7E-06	2E-03	7E-03	—	1E-02	4E-04	3E-04	—	7E-04	3E-02	3E-02	—	5E-02	4E-04	3E-04	—	7E-04
		Arsenic	6E-05	2E-05	—	9E-05	4E-01	2E-01	—	6E-01	2E-04	2E-05	—	2E-04	5E+00	6E-01	—	6E+00	3E-04	5E-05	—	3E-04
Southwest Landfill Area	Tap Water	Benzene	2E-05	2E-06	2E-05	3E-05	2E-01	3E-02	2E-01	5E-01	1E-05	1E-06	1E-05	3E-05	7E-01	8E-02	7E-01	2E+00	3E-05	4E-06	3E-05	6E-05
		1,1-Dichloroethene	—	—	—	—	3E-01	4E-02	3E-01	7E-01	—	—	—	—	1E+00	1E-01	1E+00	2E+00	—	—	—	—
		Vinyl Chloride	1E-03	—	1E-03	2E-03	2E+00	—	2E+00	3E+00	1E-02	—	1E-02	3E-02	6E+00	—	6E+00	1E+01	2E-02	—	2E-02	3E-02
		Arsenic	1E-03	—	—	1E-03	9E+00	—	—	9E+00	1E-03	—	—	1E-03	3E+01	—	—	3E+01	3E-03	—	—	3E-03
		Manganese	—	—	—	—	4E+00	—	—	4E+00	—	—	—	—	1E+01	—	—	1E+01	—	—	—	—
	Irrigation Water	Vinyl Chloride	5E-06	1E-05	—	2E-05	6E-03	2E-02	—	2E-02	9E-04	8E-04	—	2E-03	7E-02	6E-02	—	1E-01	9E-04	8E-04	—	2E-03
		Arsenic	5E-06	2E-06	—	7E-06	3E-02	1E-02	—	5E-02	2E-05	2E-06	—	2E-05	4E-01	5E-02	—	5E-01	2E-05	4E-06	—	2E-05
Southwest Area	Tap Water	Vinyl Chloride	3E-05	—	3E-05	6E-05	4E-02	—	4E-02	8E-02	3E-04	—	3E-04	7E-04	1E-01	—	1E-01	3E-01	4E-04	—	4E-04	8E-04
		Arsenic	5E-04	—	—	5E-04	3E+00	—	—	3E+00	5E-04	—	—	5E-04	1E+01	—	—	1E+01	1E-03	—	—	1E-03
		Manganese	—	—	—	—	4E+00	—	—	4E+00	—	—	—	—	1E+01	—	—	1E+01	—	—	—	—

Notes:

Areas and exposure media shown have an associated total cancer risk > 10^{-4}, target organ-specific HI>1, or both.

Chemicals presented for each area have an associated cancer risk >10^{-4}, target organ-specific HI>1, or both.

Table 2-9. Summary of Number of Locations with Risk Causing Chemicals within each Geographic Area.

Feasability Study Area	Compound	PRG (µg/L)[a]	No. Locations > PRG / Total No. Locations	Maximum Concentration Detected (µg/L)
Assabet River Area				
	1,1-Dichloroethene	7	3 / 17	420
	Arsenic	10	2 / 17	28.8
	Benzene	5	2 / 17	16
	Manganese	844	4 / 17	2470
	Vinyl Chloride	2	4 / 17	100
Former Lagoon Area				
	1,1-Dichloroethene	7	18 / 30	140
	Arsenic	10	12 / 29	541
	Benzene	5	2 / 30	55
	Manganese	844	13 / 29	5340
	Vinyl Chloride	2	13 / 30	27
Northeast Area				
	1,1-Dichloroethene	7	15 / 43	260
	Arsenic	10	4 / 42	45.9
	Benzene	5	4 / 43	9.5
	Manganese	844	6 / 42	1170
	Methylene Chloride	5	2 / 43	13
	Vinyl Chloride	2	8 / 43	21
Southeast Landfill Area				
	1,1-Dichloroethene	7	10 / 37	140
	1,2-Dichloroethane	5	11 / 37	120
	1,2-Dichloropropane	5	6 / 37	90
	Arsenic	10	13 / 37	1240
	Benzene	5	24 / 37	6000
	bis (2-ethylhexyl) phthalate	6	1 / 13	7.5
	Manganese	844	19 / 37	13000
	Methylene Chloride	5	4 / 37	140
	Vinyl Chloride	2	15 / 37	100
Southwest Area				
	1,1-Dichloroethene	7	2 / 22	11
	Arsenic	10	2 / 25	37.9
	Manganese	844	9 / 25	3720
	Vinyl Chloride	2	1 / 22	4.7
Southwest Landfill Area				
	1,1-Dichloroethene	7	13 / 24	660
	Arsenic	10	8 / 24	181
	Benzene	5	11 / 24	32
	Manganese	844	8 / 24	5660
	Vinyl Chloride	2	13 / 24	200

[a]- The maximum detected background concentration for manganese of 844 µg/L is listed for screening purposes.
- Summary includes groundwater samples collected between September 1999 and June 2002, which are the groundwater samples considered in the Public Health Risk Assessment (Menzie-Cura, 2005a).

Table 2-10. Summary of Human Health Risks From Exposure to Sediment.

Exposure Point	Exposure Medium	Chemical	Adult						Child						Sum of Adult and Child		
			Cancer Risk			Non-Cancer Hazard Quotient			Cancer Risk			Non-Cancer Hazard Quotient			Cancer Risk		
			Ingestion	Dermal	Exposure Routes Total	Ingestion	Dermal	Exposure Routes Total	Ingestion	Dermal	Exposure Routes Total	Ingestion	Dermal	Exposure Routes Total	Ingestion	Dermal	Total
North Lagoon Wetland	Sediment	Arsenic	2E-04	3E-05	3E-04	2E+00	2E-01	2E+00	6E-04	4E-05	6E-04	1E+01	9E-01	2E+01	8E-04	7E-05	9E-04
Sinking Pond	Sediment	Arsenic	1E-04	1E-05	1E-04	7E-01	9E-02	8E-01	3E-04	2E-05	3E-04	7E+00	4E-01	7E+00	4E-04	3E-05	4E-04

Notes:

Areas and exposure media shown have an associated total cancer risk > 10^{-4}, target organ-specific HI>1, or both.

Chemicals presented for each area have an associated cancer risk >10^{-6}, target organ-specific HI>1, or both.